Status of China Spallation Neutron Source

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Institute of High Energy Physics, Chinese Academy of Science

ISINN-28, Xi'an, China, May 24th, 2021

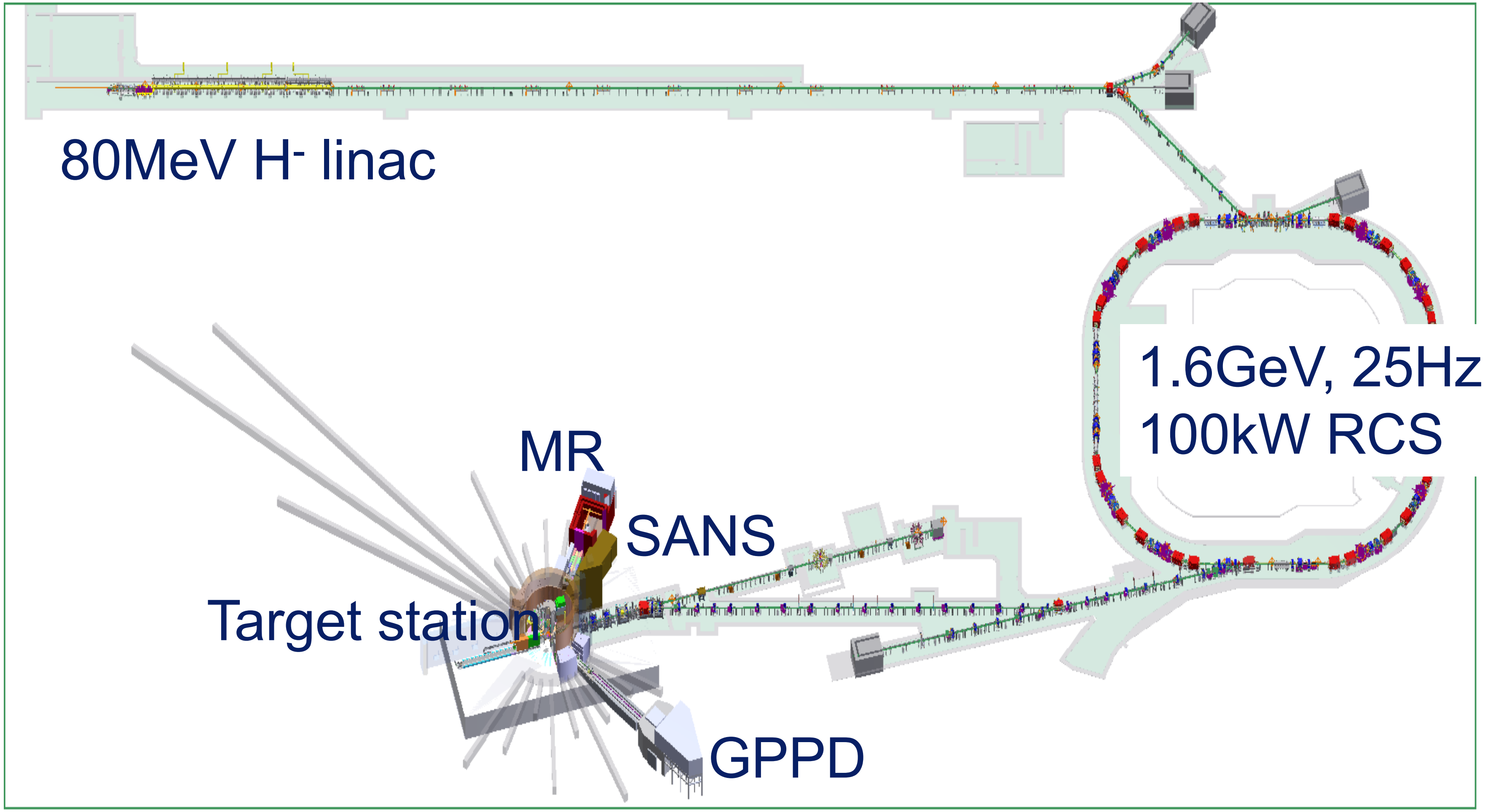



Outline

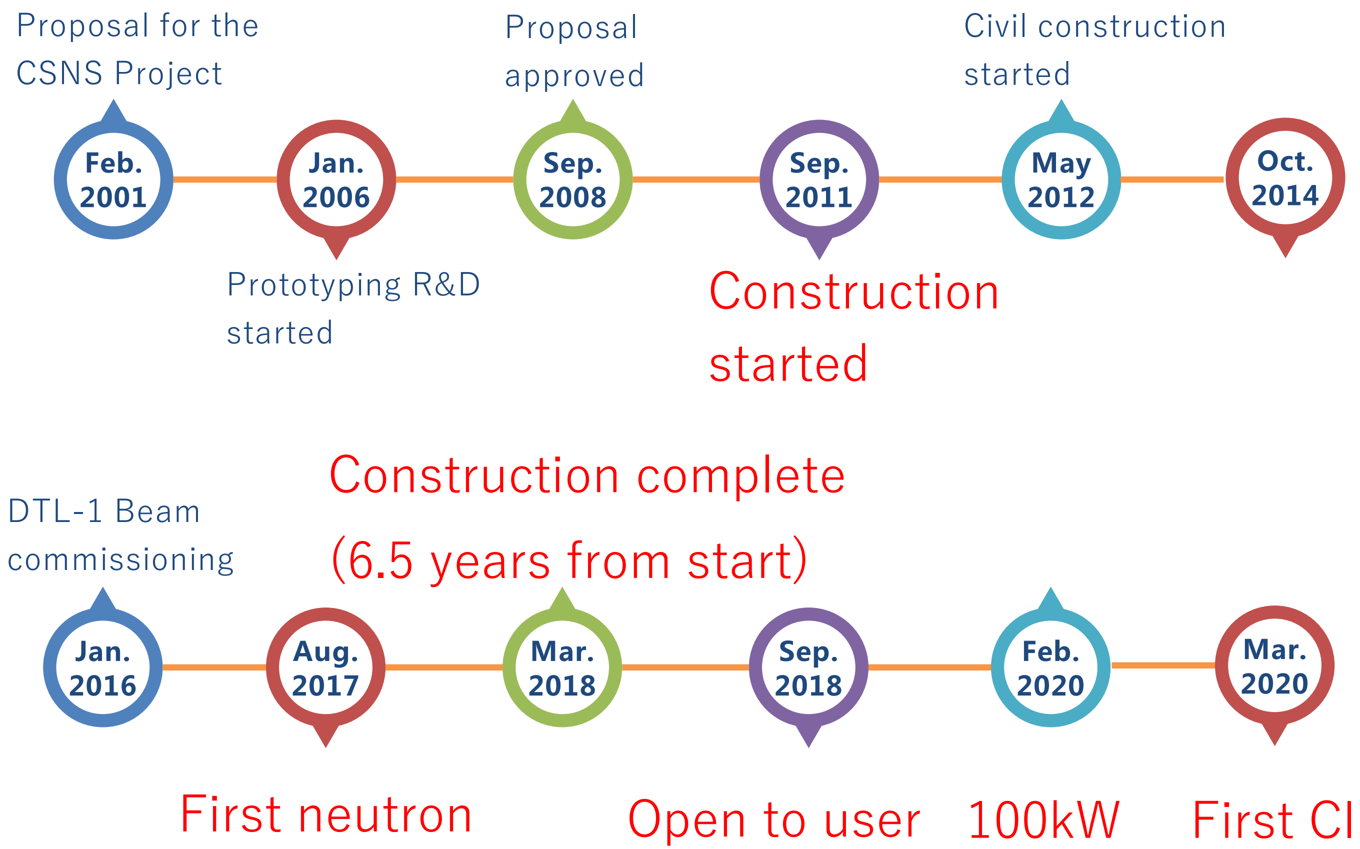
- **CSNS project overview**
- Cooperation instruments
- CSNS-II
- Summary

CSNS Layout

- The phase-I CSNS facility consists of a Linac, a 1.6-GeV 100kW, 25Hz RCS, beam transport lines, a target station, and 3 day-one instruments.



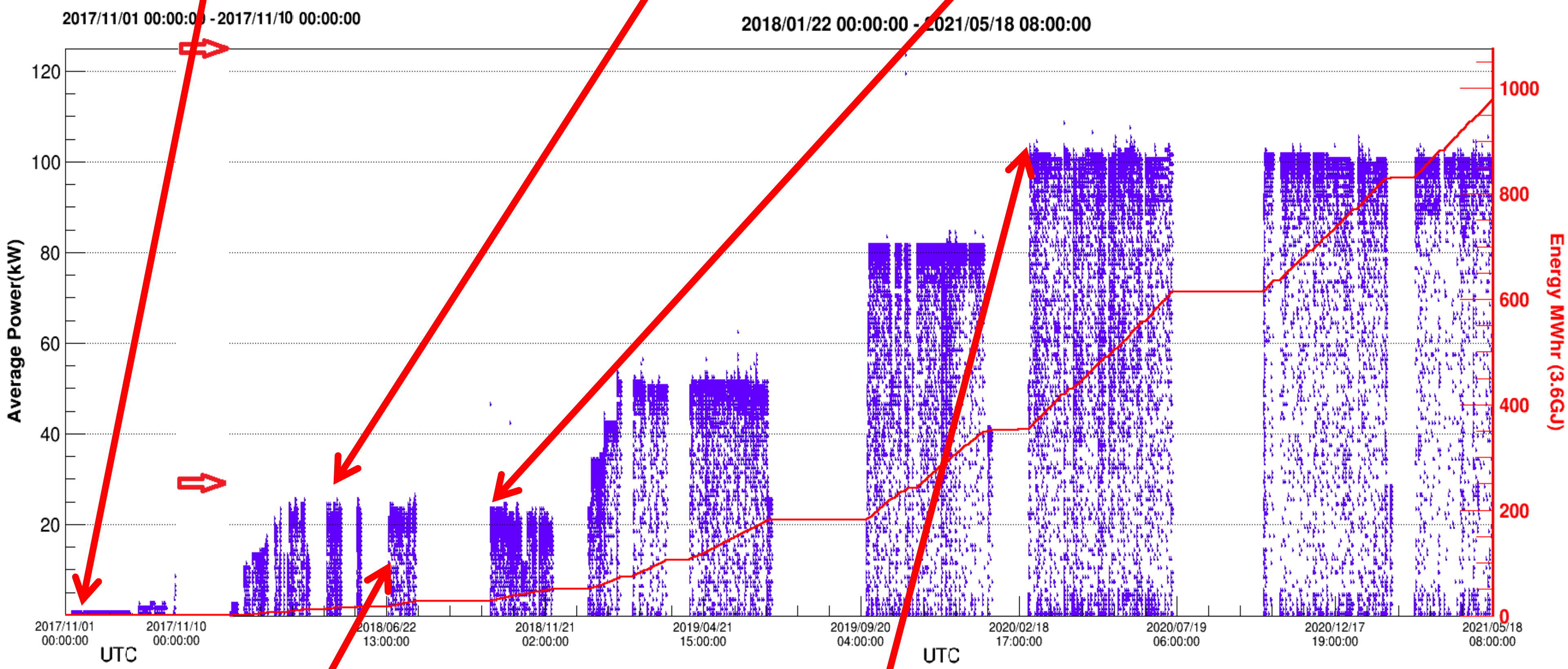
Key Milestones




Birds View of CSNS
August, 2017
RCS service building
Linac service building
Target station and instruments hall

CSNS Beam History

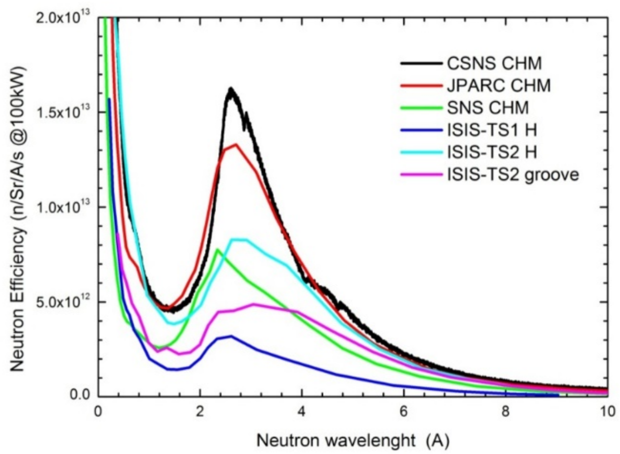
First diffraction pattern
First scientific paper
Open to user



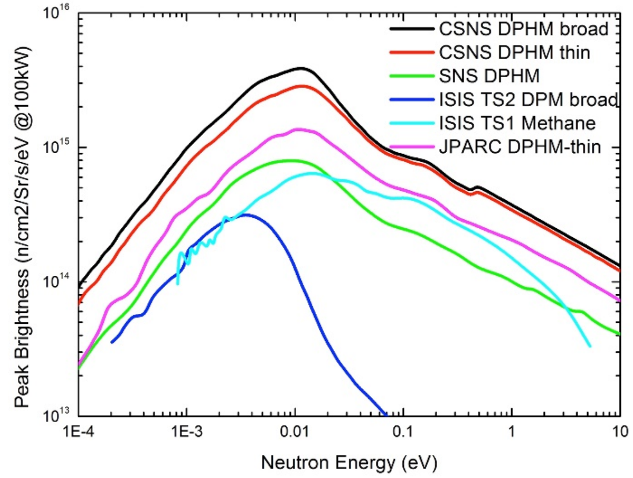
Beam availability > 90%
Beam power 100kW

Beam hours: 2018 2833h, 2019 4578h, 2020 4451h

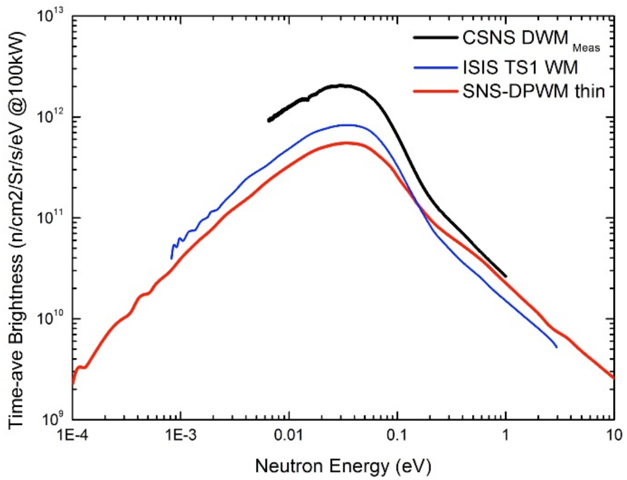
Neutronics Performance of Target Station



Wavelength spectra (CHM)



Peak brightness (DPHM)



TAV brightness (DWM)

The neutronic performance of the source (and moderators) is excellent, and provides evidence of strong coupling between the target and the moderators.

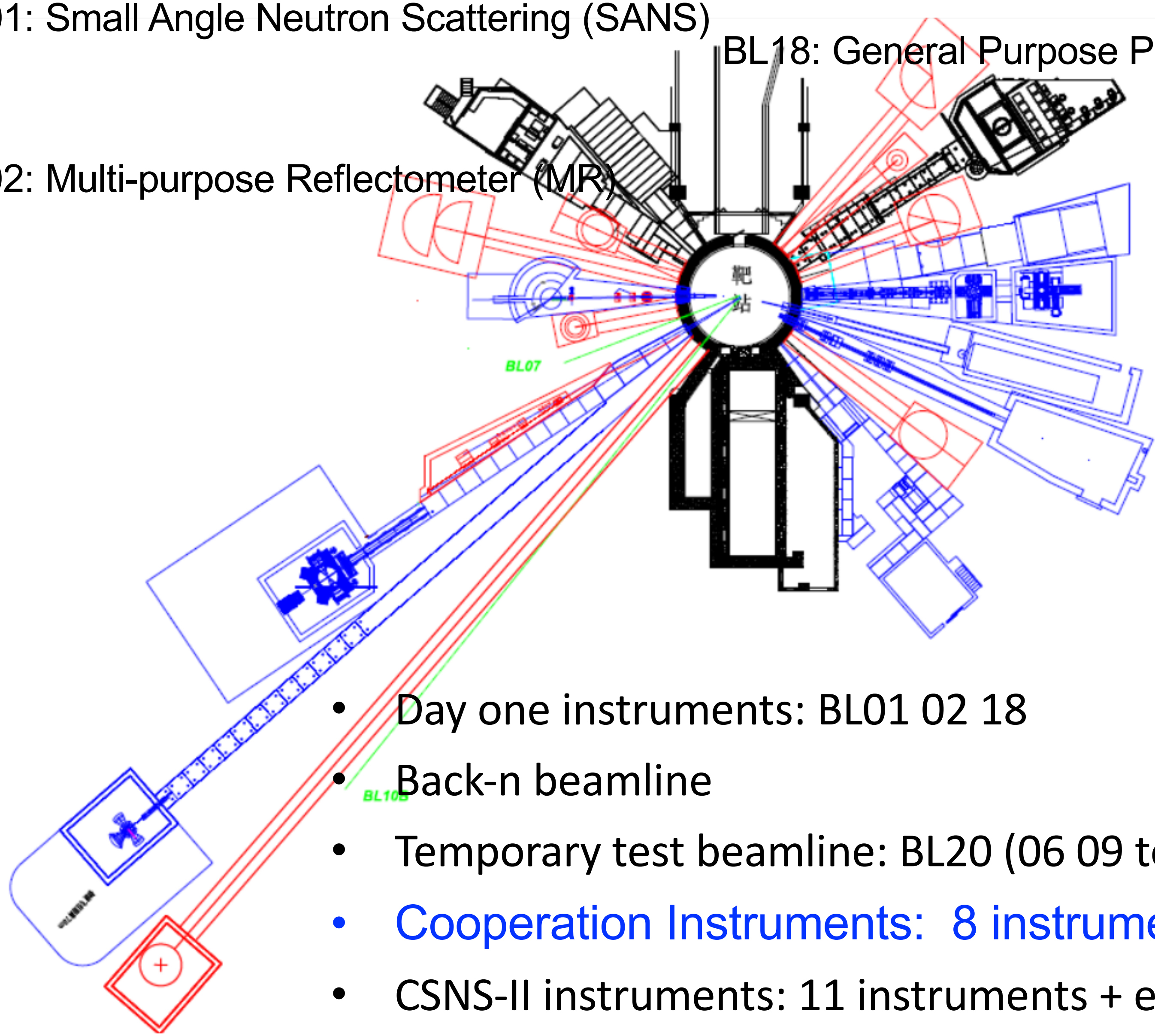
NTAC10 report, Dec， 2018

Instruments layout

BL01: Small Angle Neutron Scattering (SANS)

BL18: General Purpose Powder Diffractometer (GPPD

BL02: Multi-purpose Reflectometer (MR)



- Day one instruments: BL01 02 18
- Back-n beamline
- Temporary test beamline: BL20 (06 09 to July， 2019)
- Cooperation Instruments: 8 instrument under construction
- CSNS-II instruments: 11 instruments + experimental station

Neutron instrument: GPPD

- For most users to determine crystallographic and magnetic structures in general purposes
- Best resolution Δd/d ~ 0.14 %.
- ~ mimutes for a diffraction histogram used by Rietveld refinement on ~ 1-g-weight sample
- Easily loading the ancillary equipment such as cryostat, furnace and pressure cell

Neutron instrument: GPPD

Science

REPORTS

Cite as: L. Liu *et al.*, *Science* 10.1126/science.aba9413 (2020).

Making ultrastrong steel tough by grain-boundary delamination

L. Liu[1]*, Qin Yu[2]*, Z. Wang[1], Jon Ell[2,3], M. X. Huang[1]†, Robert O. Ritchie[2,3]†

[1]Department of Mechanical Engineering, The University of Hong Kong, Pokfulam Road, Hong Kong, China. [2]Materials Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA. [3]Department of Materials Science and Engineering, University of California, Berkeley, CA 94720, USA.

Science (May 7 2020)

L.H. He and J. Chen are acknowledged for their help on the neutron powder diffraction experiments which were performed at GPPD of the China Spallation Neutron Source (CSNS), Dongguan, China. J.H. Luan and Z.B. Jiao are

ADVANCED MATERIALS

Communication | Full Access |

A Novel NASICON-Type $Na_4MnCr(PO_4)_3$ Demonstrating the Energy Density Record of Phosphate Cathodes for Sodium-Ion Batteries

Jian Zhang, Yongchang Liu, Xudong Zhao, Lunhua He, Hui Liu, Yuzhu Song, Shengdong Sun, Q , Xianran Xing, Jun Chen

Materials Horizons

ROYAL SOCIETY OF CHEMISTRY

COMMUNICATION

View Article Online
View Journal

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Cite this: DOI: 10.1039/c9mh01602c

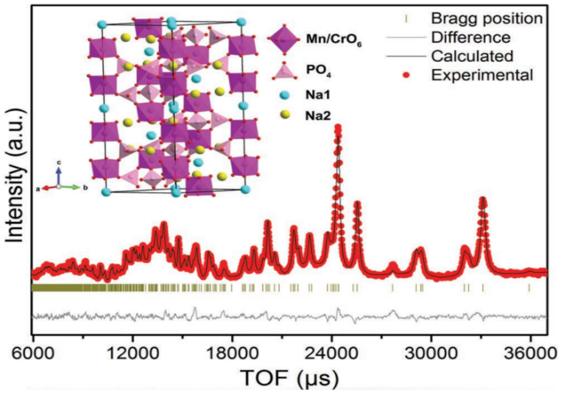
Received 8th October 2019, Accepted 25th November 2019

DOI: 10.1039/c9mh01602c

rsc.li/materials-horizons

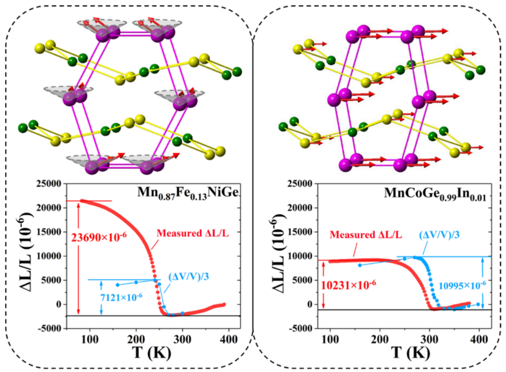
Cone-spiral magnetic ordering dominated lattice distortion and giant negative thermal expansion in Fe-doped MnNiGe compounds†

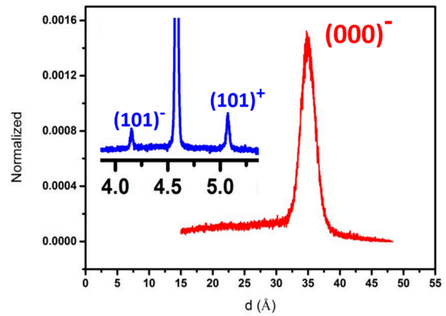
Feiran Shen,‡[abc] Houbo Zhou,‡[ab] Fengxia Hu,*[abd] Jian-Tao Wang,[abd] Sihao Deng,[c] Baotian Wang,[c] Hui Wu,[e] Qingzhen Huang,[e] Jing Wang,*[abf] Jie Chen,[c] Lunhua He,*[acd] Jiazheng Hao,[a] Zibing Yu,[ab] Feixiang Liang,[ab] Tianjiao Liang,[c] Jirong Sun[acd] and Baogen Shen*[abd]



As featured in:

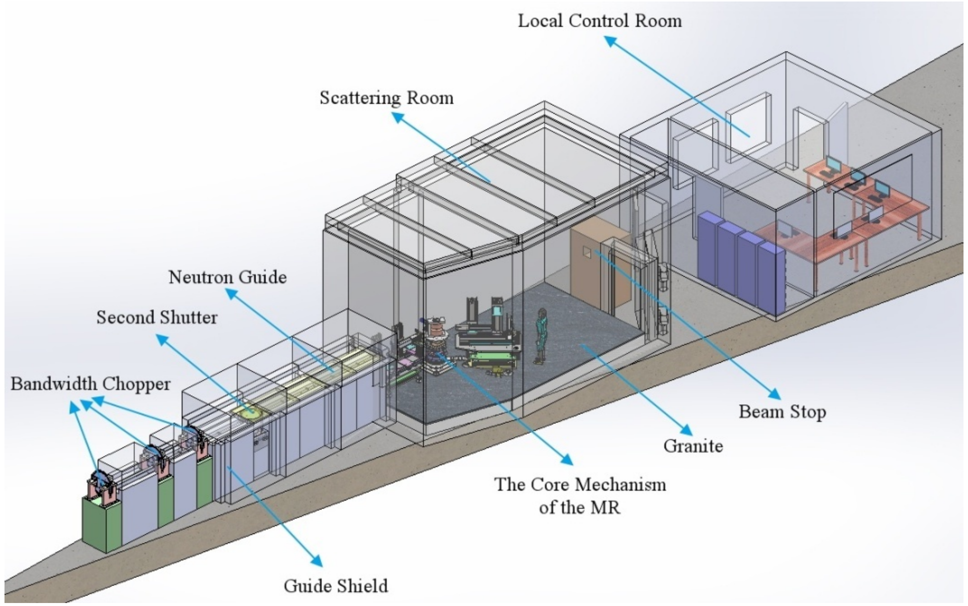
See Fengxia Hu, Jing Wang, Lunhua He, Baogen Shen *et al.*, *Mater. Horiz.*, 2020, **7**, 804.





Neutron instruments: MR

- Vertical sample geometry: solid film
- Reflectivity/diffraction
- Best resolution $\Delta Q/Q < 1\%$
- Best reflectivity: 10^{-6}
- Polarizing analysis for spinoelectronics.
- In-suit study on growing films
- In-suit MOKE magnetic analysis
- Off-specular scattering



Neutron instruments: MR

COMMUNICATION

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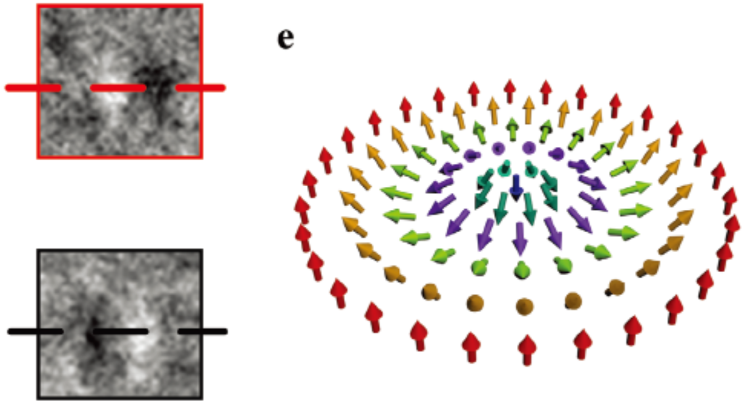
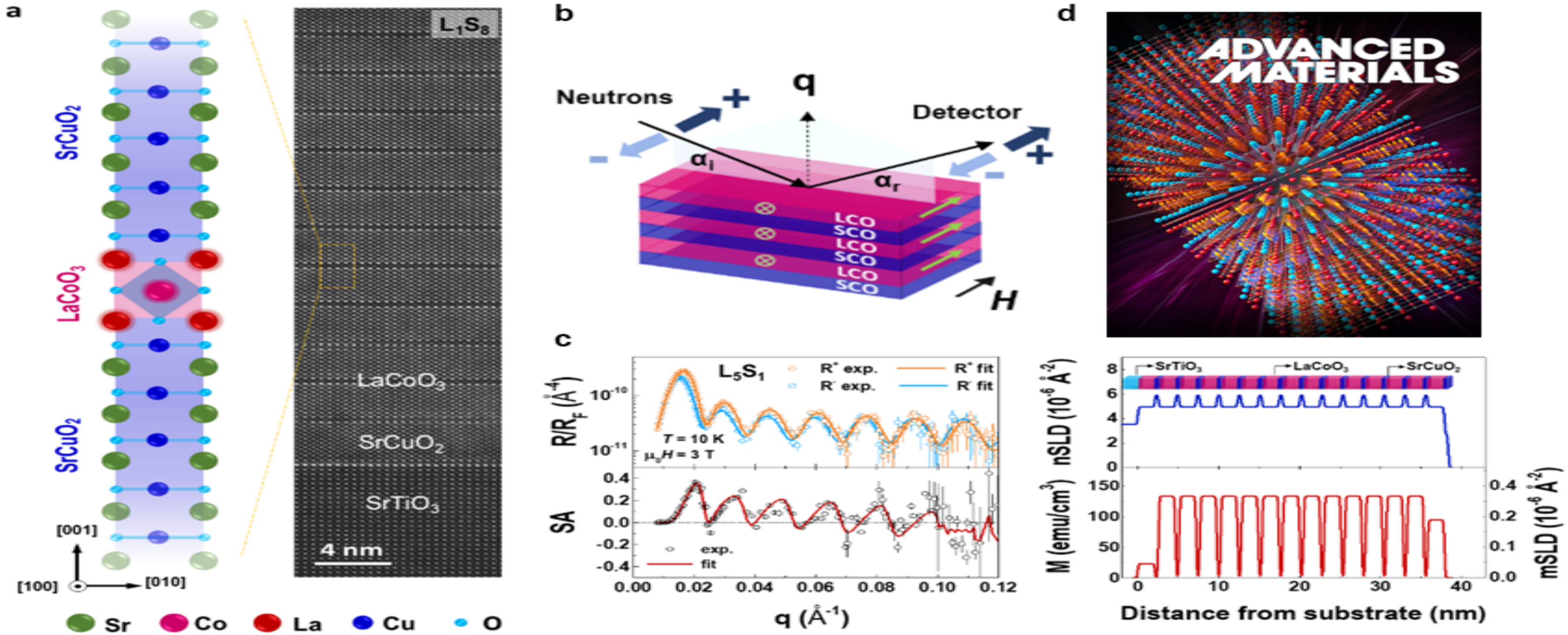
Magnetic Skyrmions in a Hall Balance with Interfacial Canted Magnetizations

Jingyan Zhang, Ying Zhang, Yang Gao, Guoping Zhao, Lei Qiu, Kaiyou Wang, Pengwei Dou, Wenlin Peng, Yuan Zhuang, Yanfei Wu, Guoqiang Yu, Zhaozhao Zhu, Yunchi Zhao, Yaqin Guo, Tao Zhu, Jianwang Cai, Baogen Shen, and Shouguo Wang**





Neutron instruments: SANS

- Reliable SANS data between 0.005~0.5 $Å^{-1}$, to characterize 1-125 nm particles.
- Instrument resolution better than ~30% around Qmin
- Good dynamic range, sample space
- Variable sample size

Moderator	CHM（20K）
MS distance	14 m
SD distance	1~5 m
Detector	
Effective area	50×50 cm^2
Resolution	1 cm (FWHM)
Δλ	0.4-8 Å
q range	0.004-3.4 $Å^{-1}$

Neutron instruments: SANS

Angewandte Chemie International Edition — GDCh — A Journal of the German Chemical Society

Research Article

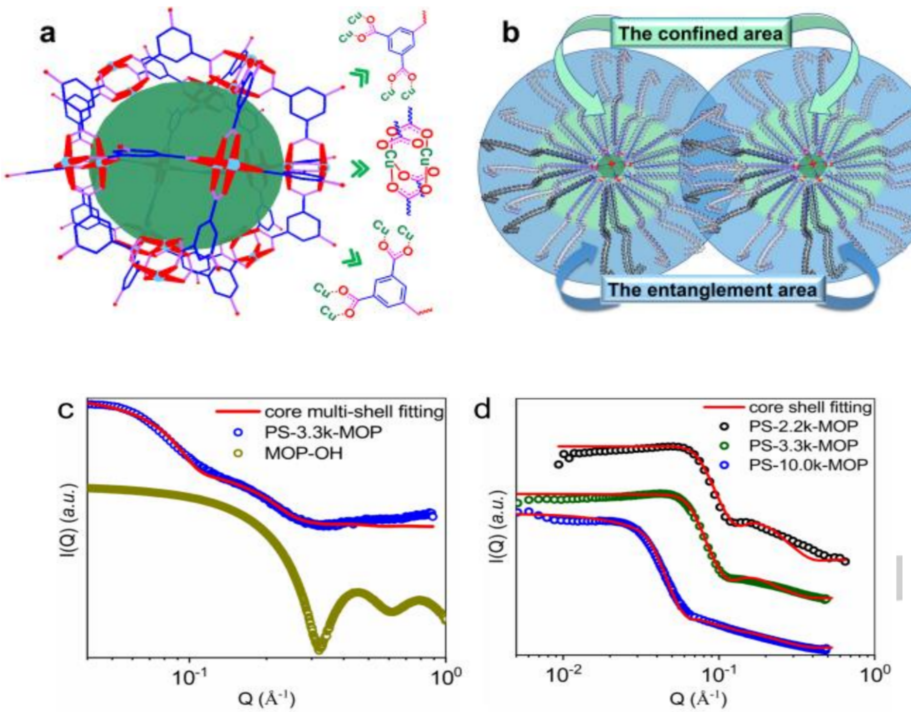
The Microscopic Structure–Property Relationship of Metal–Organic Polyhedron Nanocomposites

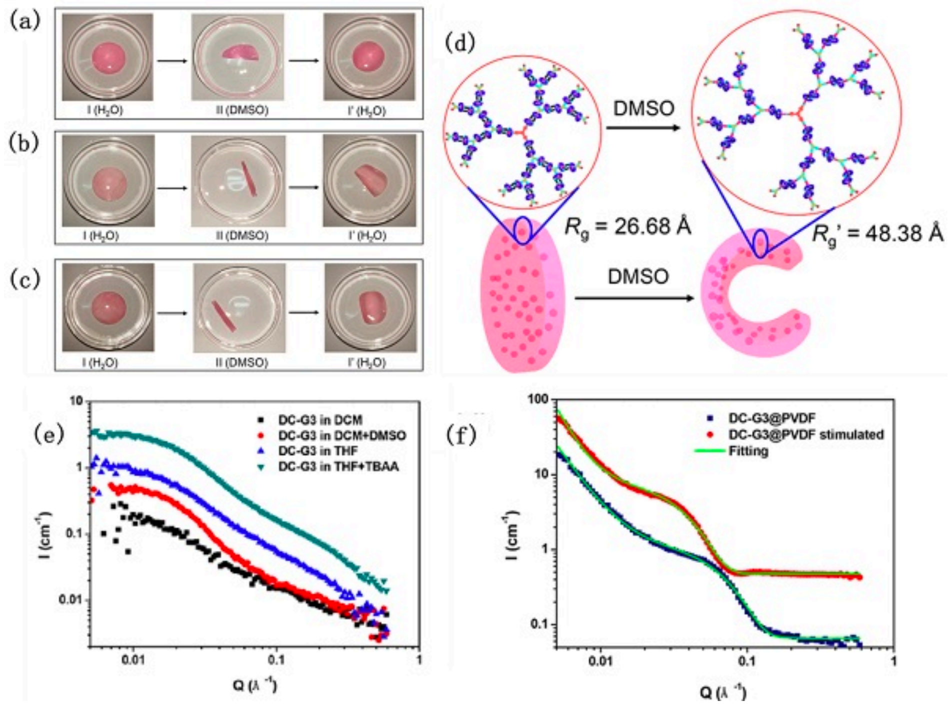
Mingxin Zhang, Yuyan Lai, Mu Li, Dr. Tao Hong, Dr. Weiyu Wang, Haitao Yu, Lengwan Li, Qianjie Zhou, Dr. Yubin Ke, Dr. Xiaozhi Zhan, Prof. Dr. Tao Zhu, Prof. Dr. Caili Huang ✉, Prof. Dr. Panchao Yin ✉

Daisy Chain Dendrimers: Integrated Mechanically Interlocked Molecules with Stimuli-Induced Dimension Modulation Feature

Wei-Jian Li, Wei Wang*, Xu-Qing Wang, Mu Li, Yubin Ke, Rui Yao, Jin Wen*, Guang-Qiang Yin, Bo Jiang, Xiaopeng Li, Panchao Yin, and Hai-Bo Yang*

Cite this: *J. Am. Chem. Soc.* 2020, 142, 18, 8473–8482
Publication Date: April 17, 2020
https://doi.org/10.1021/jacs.0c02475





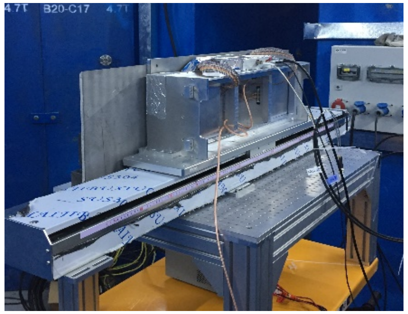
Test beamline

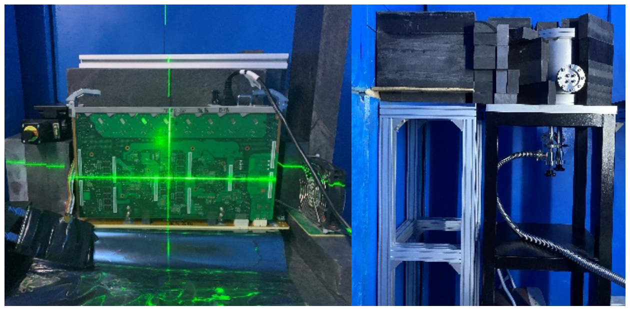
– Neutronics study of Target Station

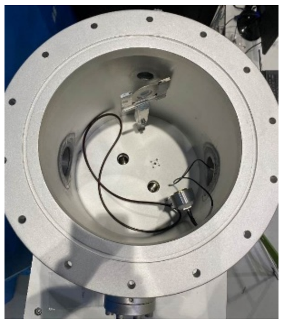
– Neutron instrumentation

– Neutron technique & methods

– Neutron SEE / NPD/ PGNAA …







Science Bulletin 66 (2021) 133–138

Contents lists available at ScienceDirect

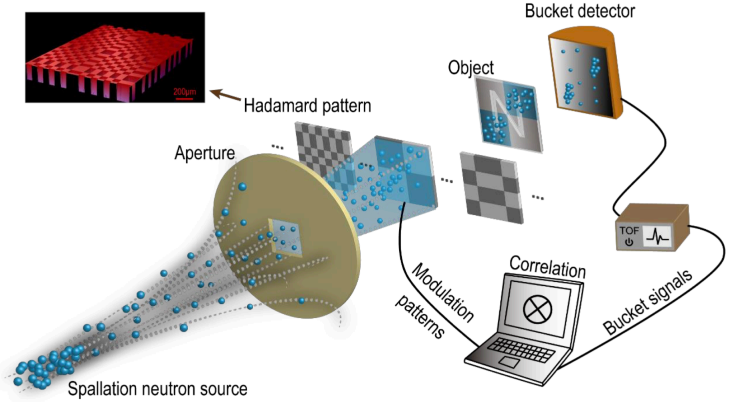
Science Bulletin

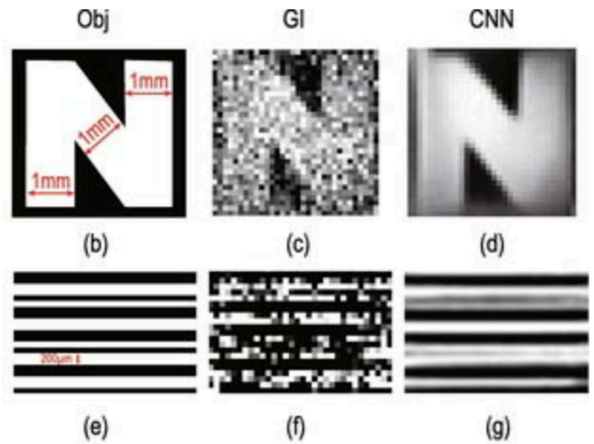
journal homepage: www.elsevier.com/locate/scib

Article

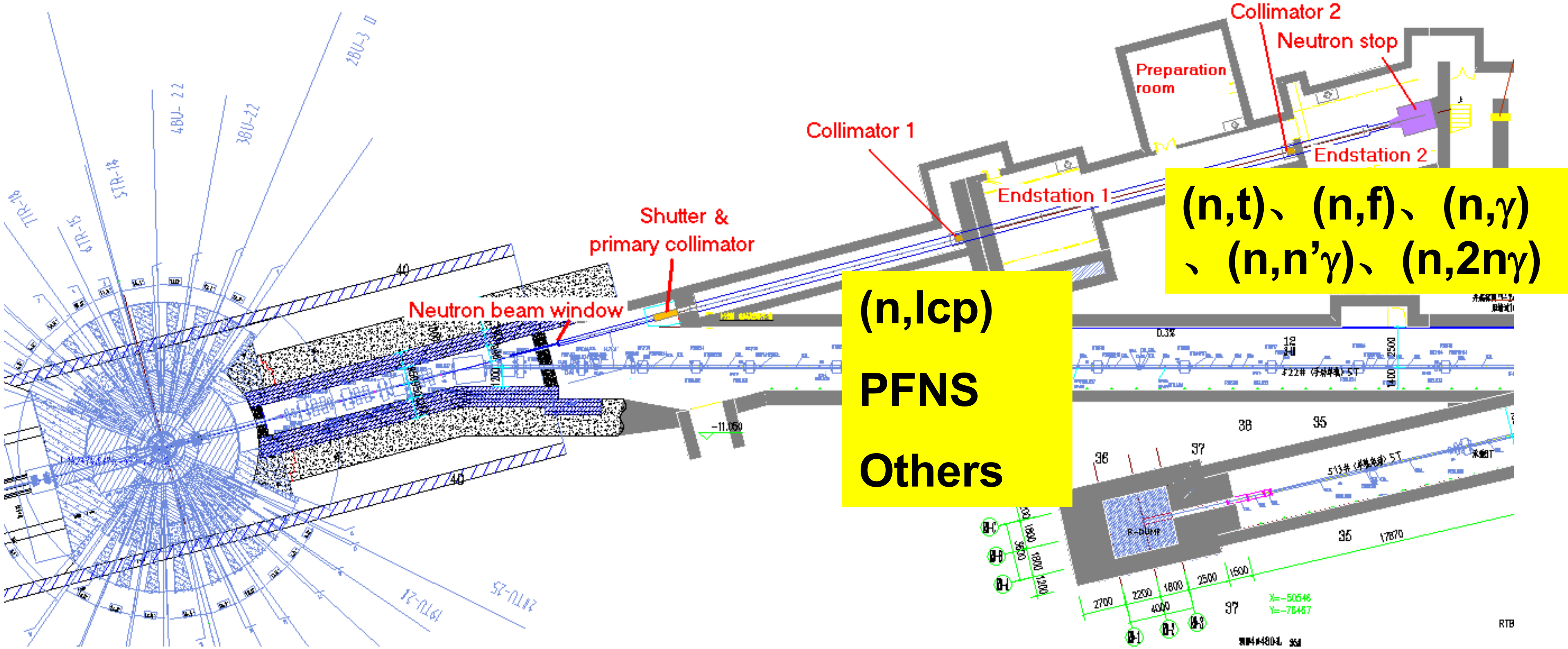
Single-pixel imaging with neutrons

Yu-Hang He [a,b,1], Yi-Yi Huang [a,b,1], Zhi-Rong Zeng [c,d,1], Yi-Fei Li [a,b], Jun-Hao Tan [a,b], Li-Ming Chen [e,f,*], Ling-An Wu [a,b,*], Ming-Fei Li [g], Bao-Gang Quan [a,b], Song-Lin Wang [c,d], Tian-Jiao Liang [c,d,*]





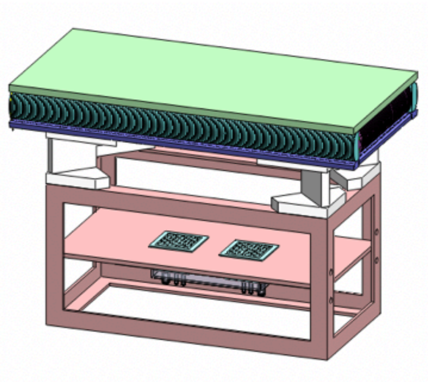
Back-n (Tang Jingyu's presentation)

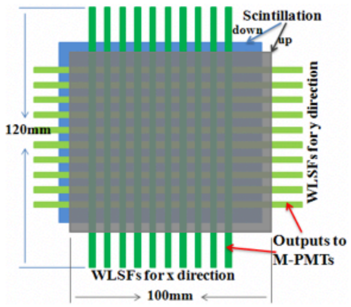


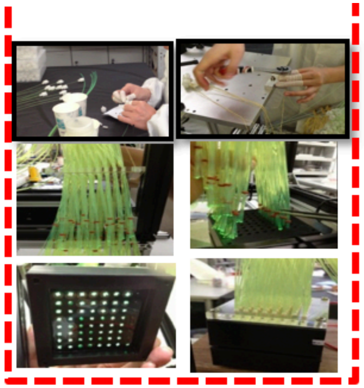
Summary/Conclusions

- A new ^{7}Li R-matrix analysis, extended to 8 MeV incident neutron energy, forms the basis for a new evaluation of the n+^{6}Li reactions.
- The data for most reactions are fit well, including the extensive new CSNS data set of Bai et al., which may be overall the most complete, and best-quality, set of relative differential cross sections for the ^{6}Li(n,t)^{4}He reaction that presently exists at energies below 3 MeV.

Neutron detector (Sun Zhijia’s presentation)







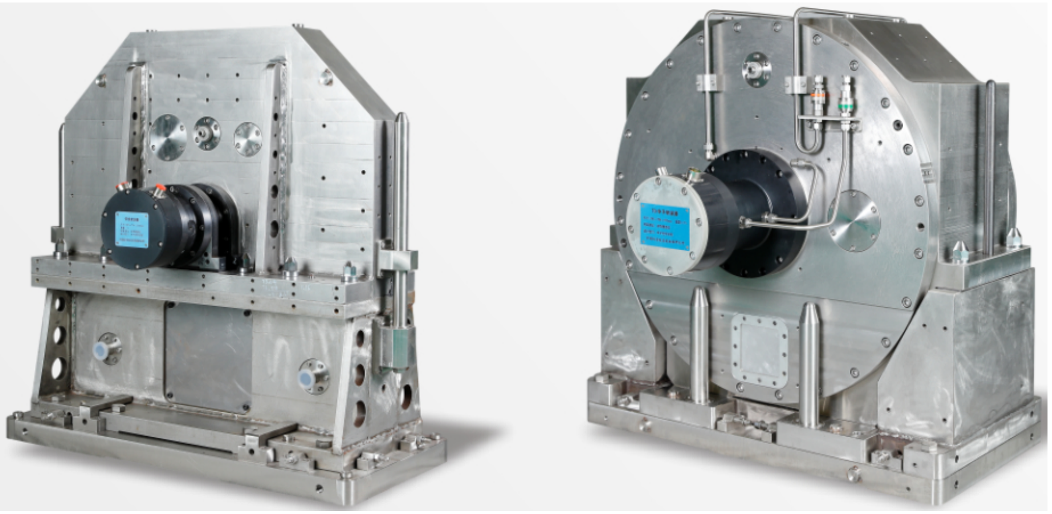
Time	2010~2018	2018~2021	2022~2028
Goals	**Scintillation detector V1** ➢ Breakthrough 0->1 ➢ PMT readout ➢low-cost and large solid angle coverage replacing ^{3}He tubes. ➢Dedicated ASIC readout electronics to realize the integration with detectors complted	**Scintillation detector V2** ➢SiPM readout, solve the probelm of non-uniformity of detection efficiency. ➢the optical fiber is bent at 90 degrees, reduce the dead zone of detection. ➢ Self-production on key components： • Transparent ceramics: LiF/ZnS(Ag) • Domestic LiF/ZnS(Ag) screen • SiPM readout	**Scintillation detector V3** **Ultra-thin new structure** **（There is no detector of the same type in the world）** ➢Thickness smaller than10cm without fibers，simplify the installation process and reduce the cost. ➢the scintillation screen inclined to improve the detection efficiency （50%@1Å）
Application	GPPD	GPPD-II(upgrade) ERNI, EMD and HP diffractometer	CSNS Phase II

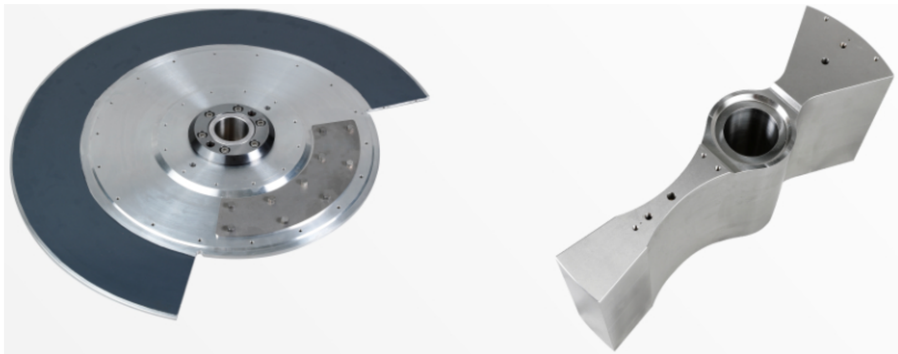
Neutron Chopper

- developed and manufactured 14 sets of choppers for four neutron instruments of CSNS.

- mass-producing 20 sets choppers for CSNS cooperation instruments.

- very low vibrations(T0 chopper: ~0.2mm/s@50Hz, bandwidth disk chopper : ~0.14mm/s@50Hz), which will have longer maintenance interval(~10 years).



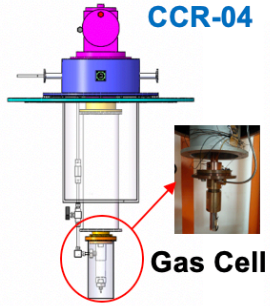


Sample Environments

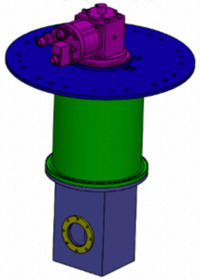
List of the Developed SE Equipment

	Code	Equipment Name	Parameters	Beamline Used
1	CCR-04	Bottom Loading Cryostat	10-325K，20MPa	CSNS-GPPD
2	CCR-05	Bottom Loading Cryostat	10-500K	CSNS-9# BL、MPI
3	HOT-03	SANS Furnace	1200℃	CSNS-SANS
4	HOT-04	Induction Heater	1500℃	(for load frame)
5	HOT-05	Flame Heater	1500℃	
6	HOT-06	Induction Heating Furnace	2600℃	
7	GP-01	Gas Panel	20MPa	CSNS-GPPD
8	CPC-01	Clamp Cell	2.0GPa	ANSTO Pelican
9	CPC-02	Clamp Cell	1.0GPa	ANSTO Pelican
10	CPC-03	Clamp Cell	0.5GPa	
11	HPC-01	CSNS Cell	5.0GPa	CMRR HPND
12	ATC-01	Sample Changer with Water Bath	-30~150℃, 18 samples	CSNS-SANS
13	ATC-02	Sample Changer with High Temperature	27~300℃, 18 samples	CSNS-SANS

CCR-04

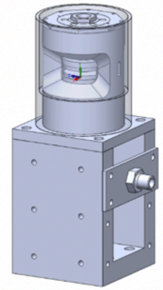


CCR-05

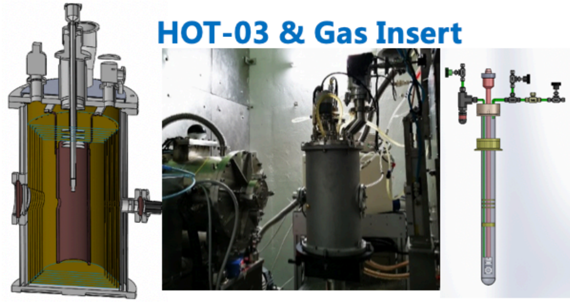


CPC-03

HPC-01

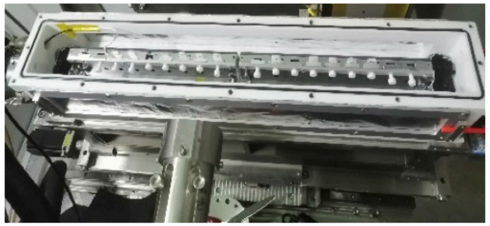


HOT-03 & Gas Insert



HOT-06

ATC-01

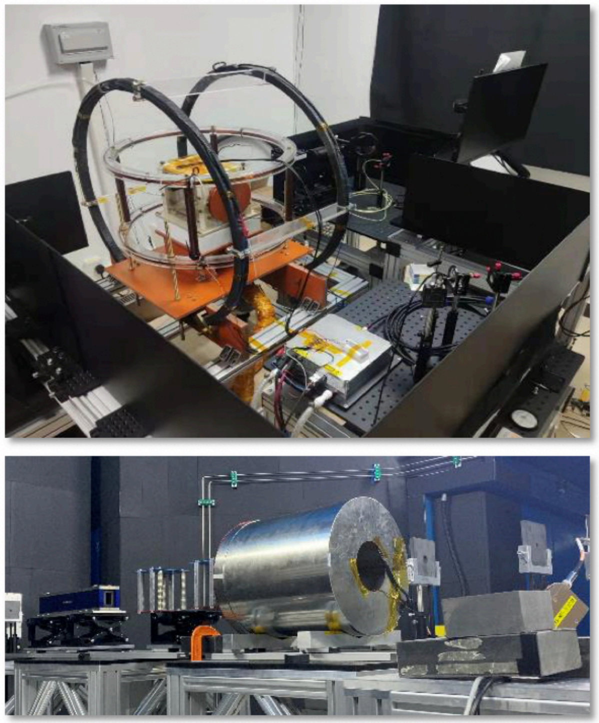


HOT-05

Neutron Polarization

- Established in-house development capability for time-of-flight polarized neutron techniques

Polarized ^{3}He pumping station

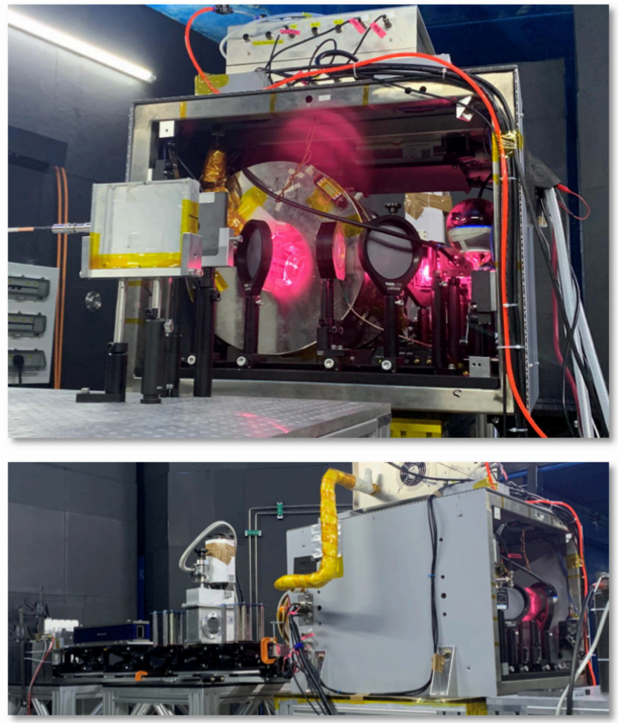


Commissioned ^{3}He polarization: 77%
^{3}He polarization lifetime: 204 h

In-house ^{3}He filling system

Manufactured ^{3}He cell lifetime: 240h
Inherent cell ^{3}He polarization: 84%

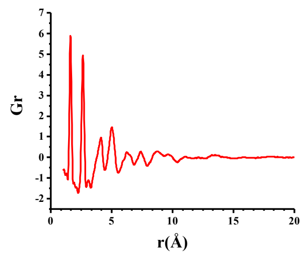
In-situ neutron polarizing system

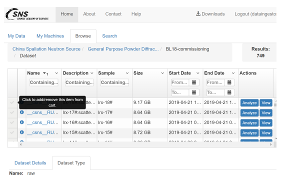


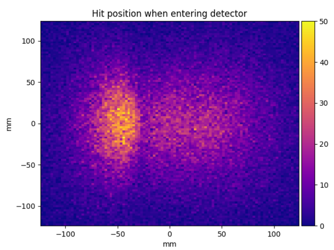
In-situ operation ^{3}He polarization: 67%
Continuous operation time: >120 h

Data analysis (Cai xiaociao's presentation)

- Develops and supports the scientific data software for neutron instrumentations, including data reduction, data analysis, computer simulation, scientific application and data management systems.







Data Reduction

Diffraction
PDF
Reflection
SANS/VSANS
GISANS
IMAGING
Inelastic
QEN

Mantid Member

Data Management

Data Portal
Data Catalogue
Data Archiving
Data Delivery
Cloud Analysis

ICAT Project

ICAT Member

Neutron Simulation

Monte Carlo Simulation
Structure & Dynamics
Neutron Cross Section

ncrystal

McStas Member

Computer Simulation

Ab-initio Computa
Molecule Dynamic
Machine Learning

User service

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

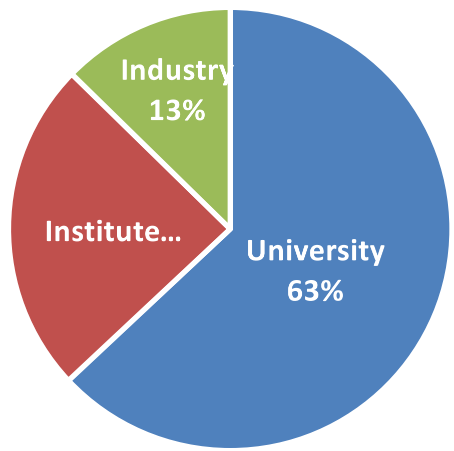
Sep. 2018 : open to user

Registration user: 2000+ (12 nation & area)

Proposal approve rate: ~30%

Completed research proposal: 350+ (about 13% from industry)

More than 60 publication



Outline

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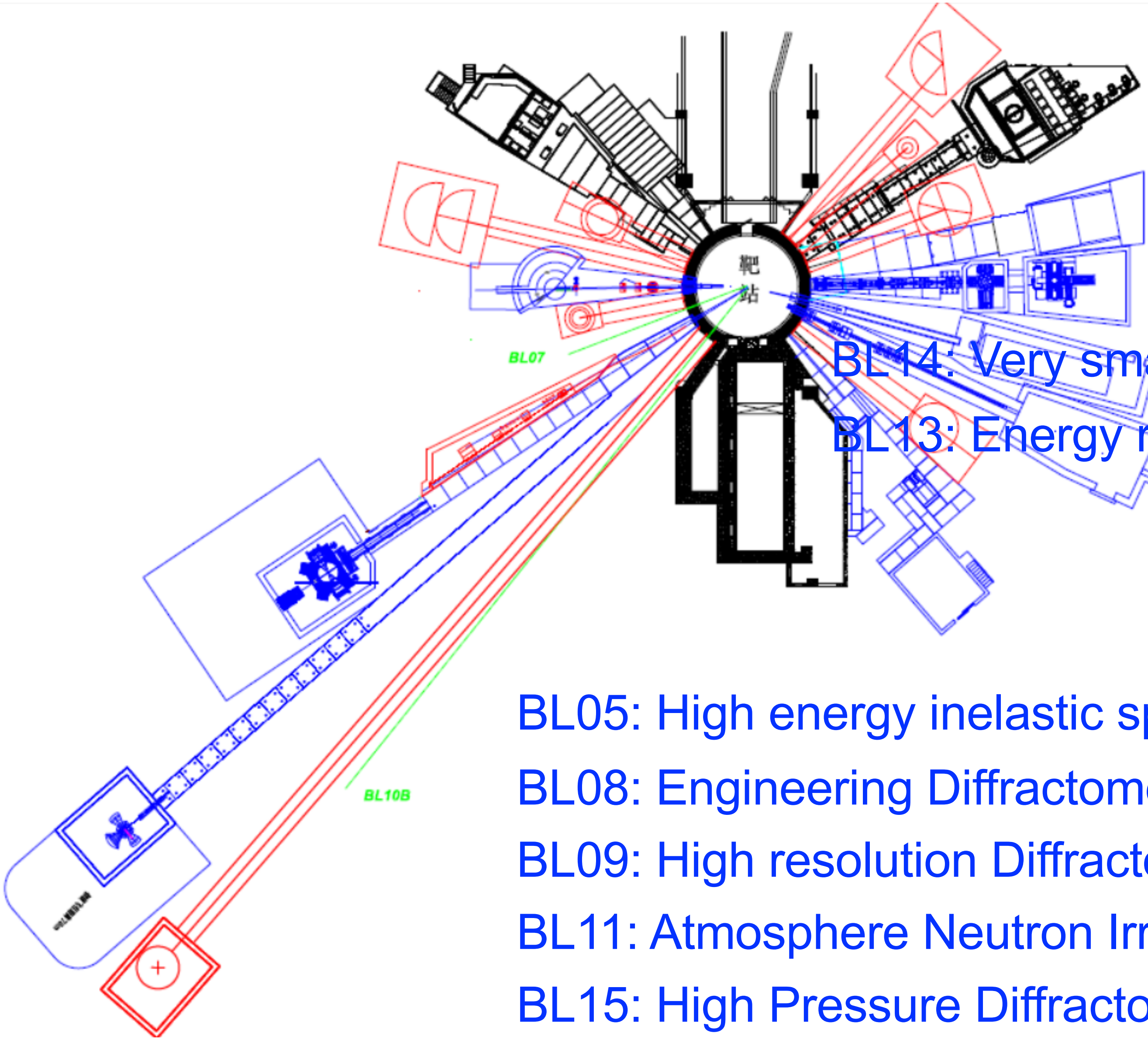
- **Cooperation instruments**
- CSNS-II
- Summary

Cooperation Instruments



BL14: Very small angle neutron scattering

BL13: Energy resolved neutron imaging

BL05: High energy inelastic spectrometer

BL08: Engineering Diffractometer

BL09: High resolution Diffractometer

BL11: Atmosphere Neutron Irradiation

BL15: High Pressure Diffractometer

BL16: Multiple Physics Instrument

Multiple Physics Instrument

MPI will be constructed as a total scattering diffractometer to study

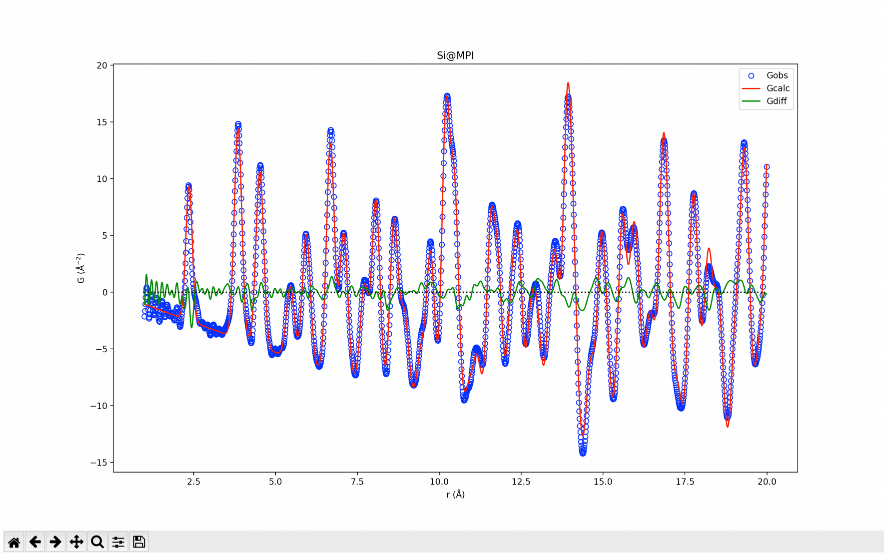
✓ the Ordered Crystalline Materials and the Ordered Crystalline Materials but with various types of Local Disorder

✓ the Disordered Materials but with Medium or Short – Range Order

Wavelength：0.1~3.0Angstrom

Q：0.1~50 Angstrom^{-1}

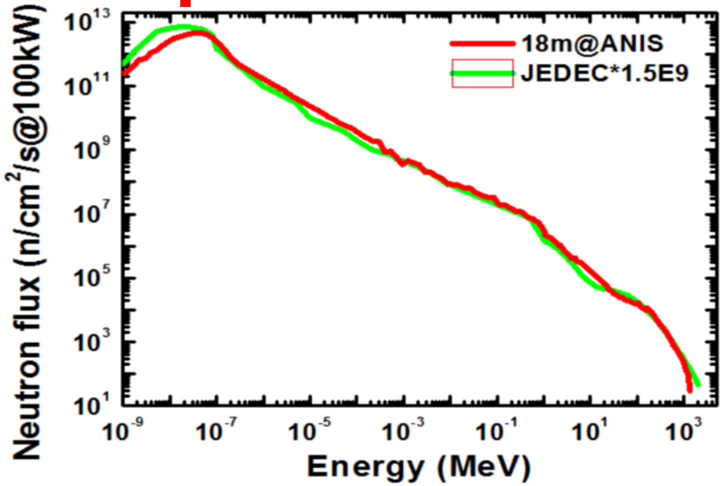
Flux at the sample position：3x10^{7} n/s/cm^{2}

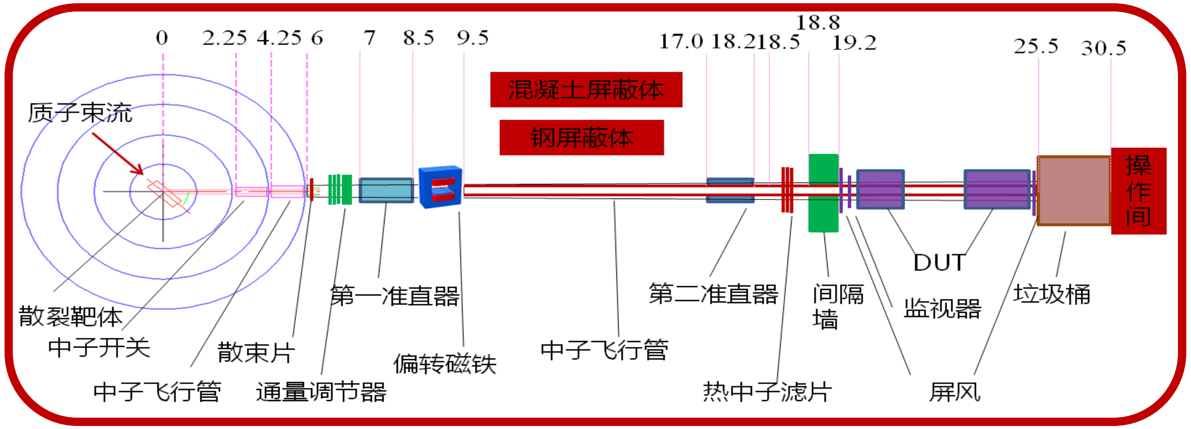


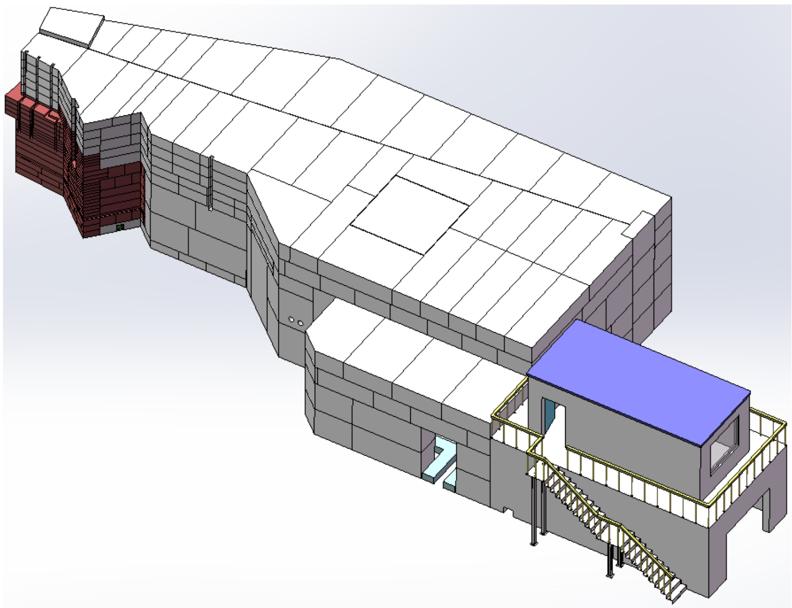
Si standard sample PDF result

Atmosphere Neutron Irradiation

Completion: Dec. 2021

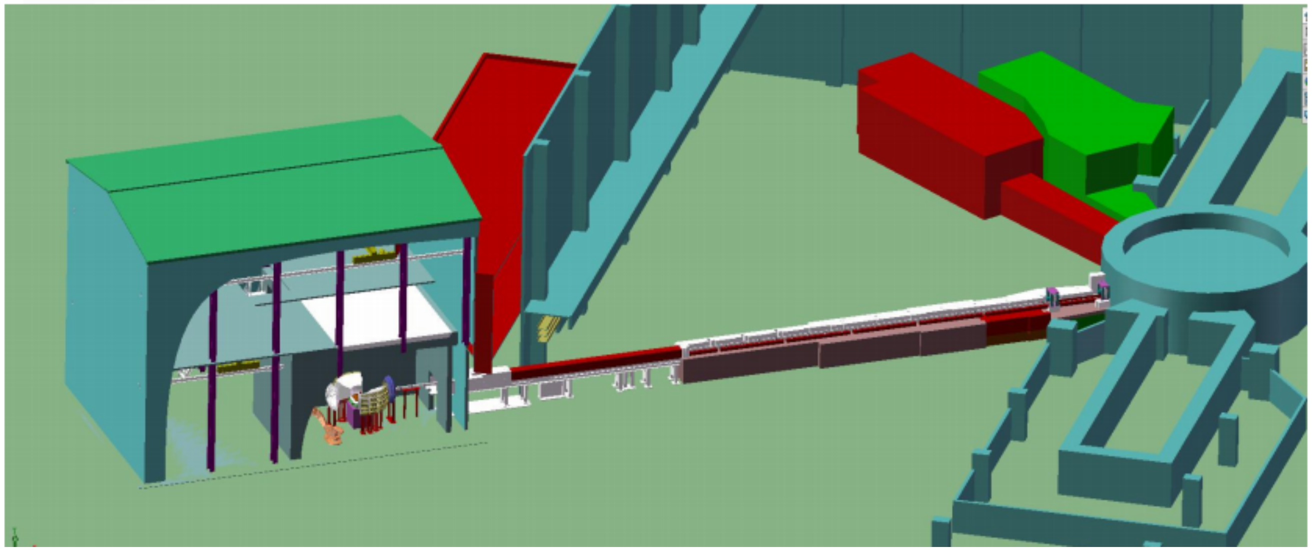


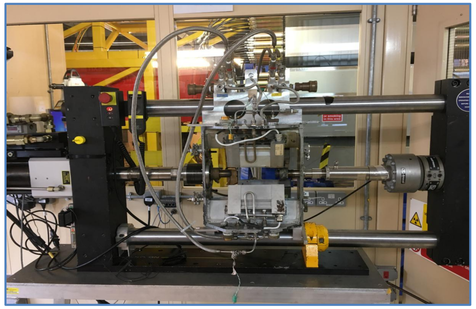


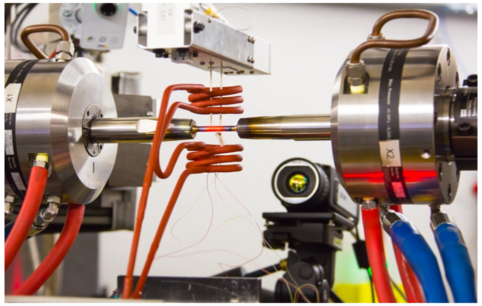


Engineering Diffractometer

Completion: July 2022



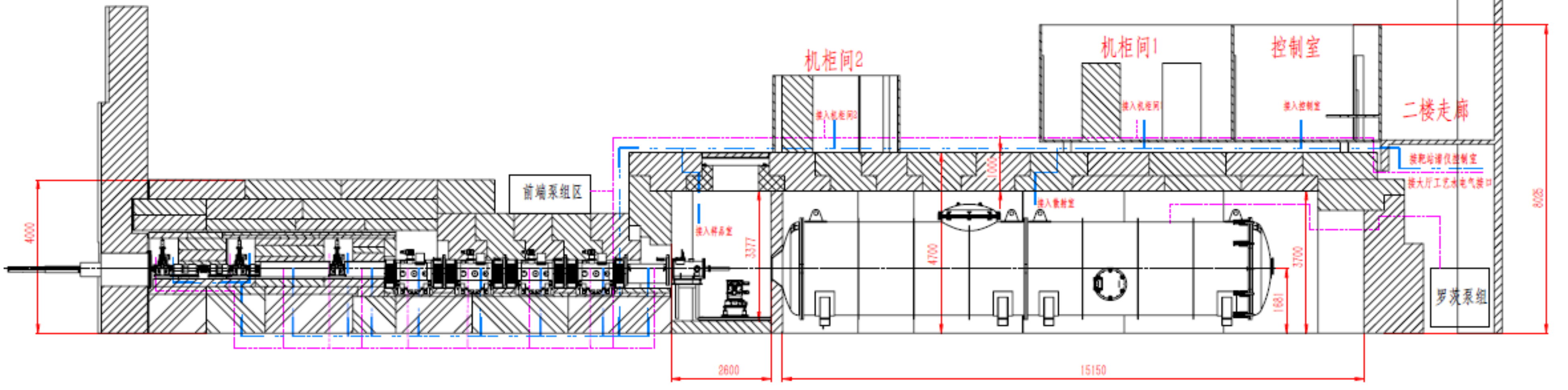


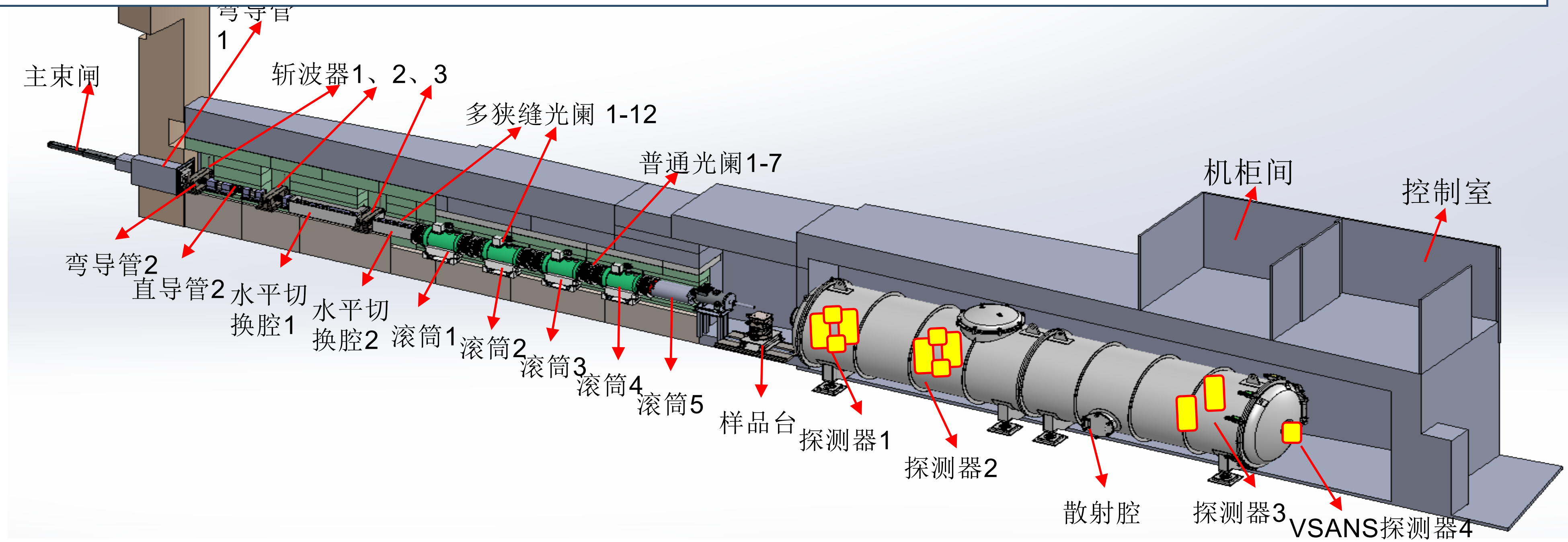


Very small angle neutron scattering

Completion: Dec 2022

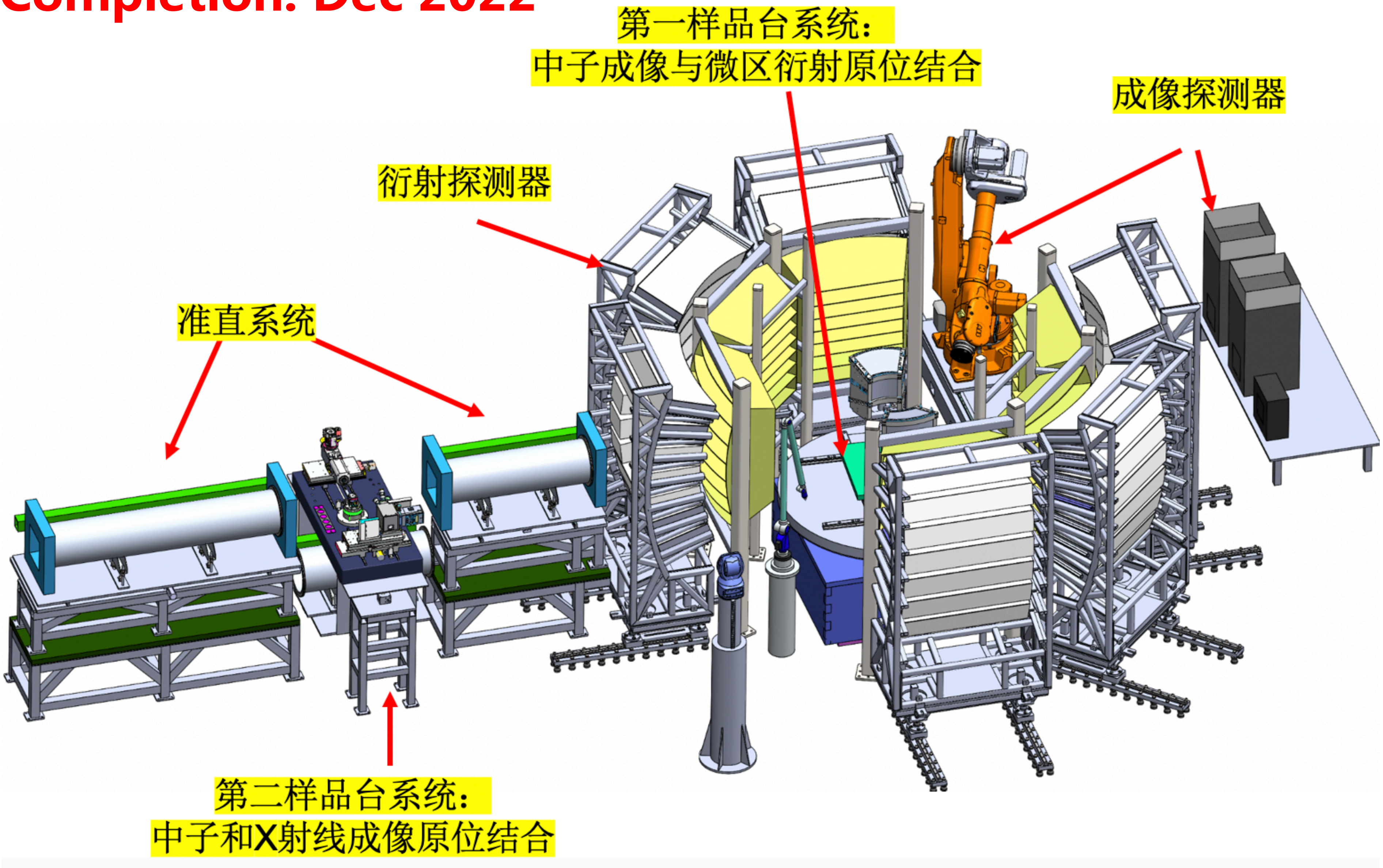
- Q range: 0.0004~1.4 Å-1
- Scale : 1-1000 nm





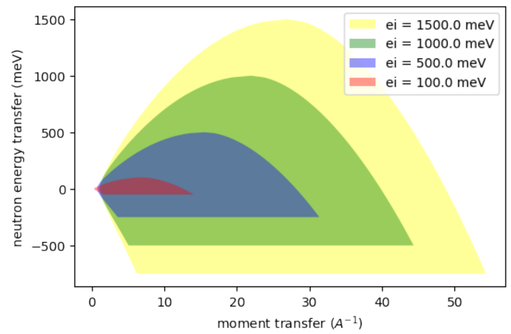
Energy resolved neutron imaging

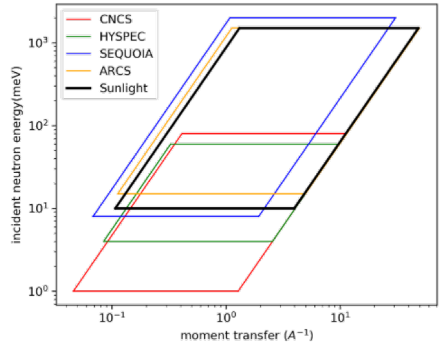
Completion: Dec 2022

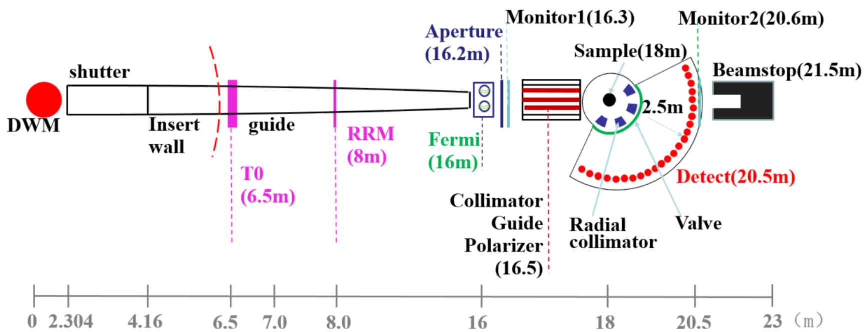


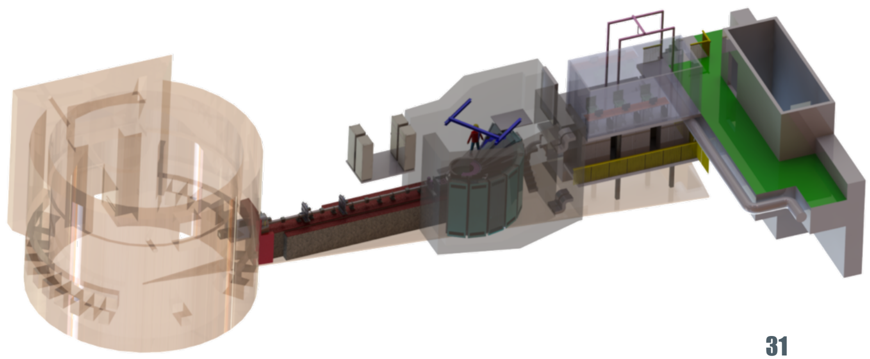
High energy inelastic spectrometer

Completion: Dec 2022





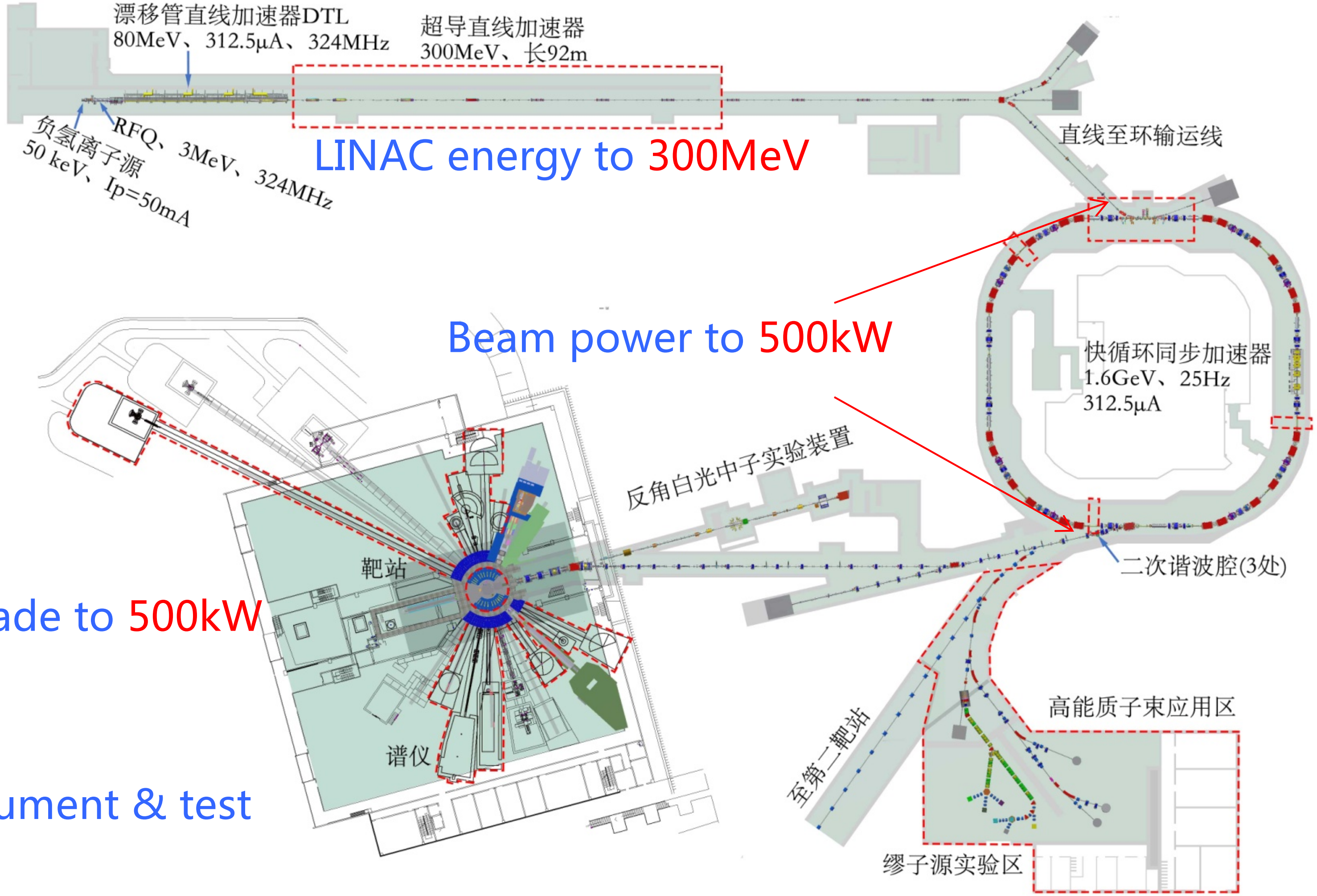




Outline

- CSNS project overview
- Cooperation instruments
- **CSNS-II**
- Summary

CSNS Phase II



TS upgrade to 500kW

New instrument & test station 11

- Under national review for 14th five year plan (2021-2015)

Challenges from accelerator & target station

- Front end: IS+ RFQ 50mA+
- DTL： 50mA+
- SC Linac：stable operation
- Energy jitter of Linac <0.02%
- Beam dynamics of RCS: the highest beam intensity in the world
- Second harmonic acceleration: High power MA loaded cavity
- High power stationary solid target for compact TMR

Phase II Instruments

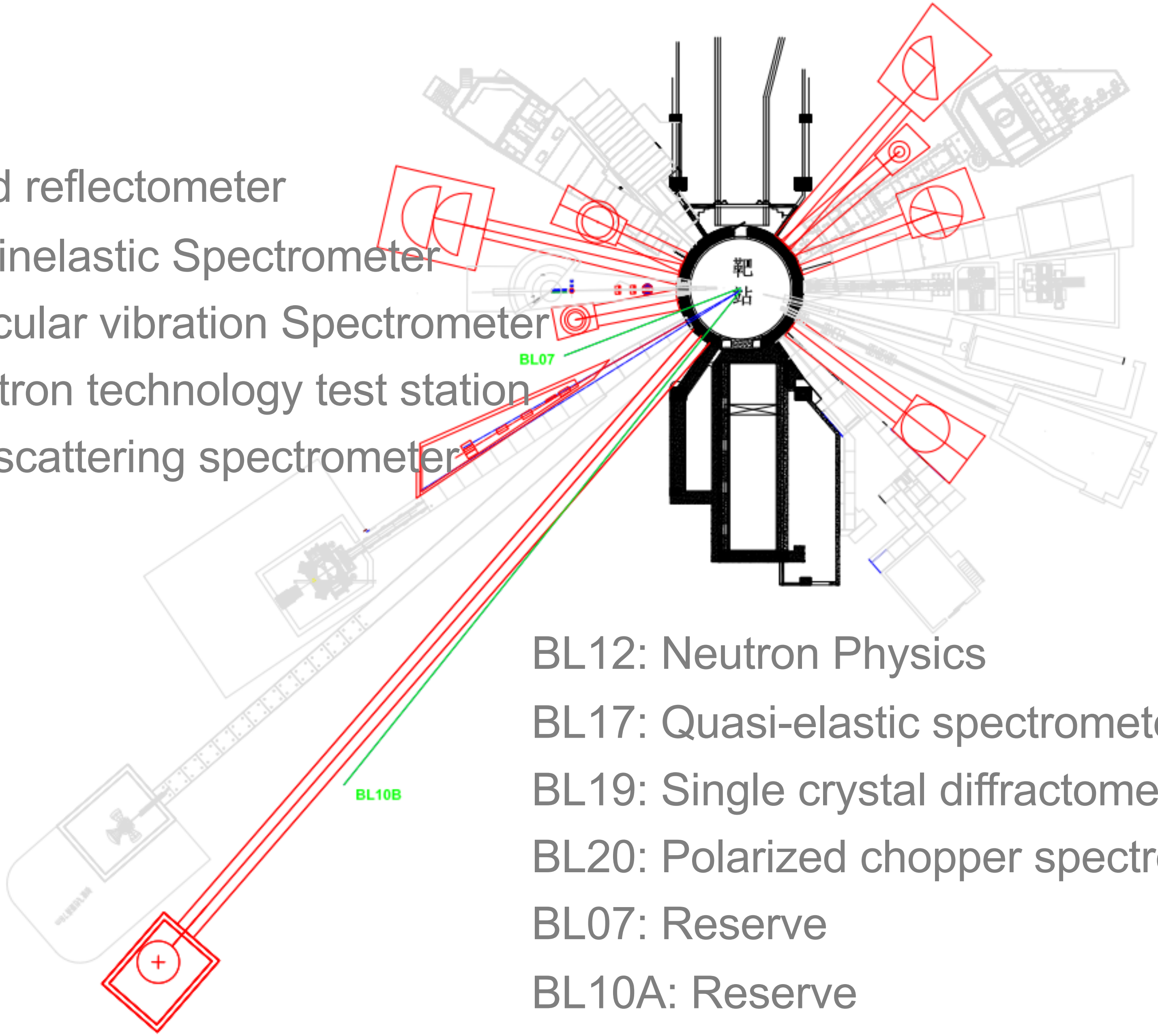
BL03: Liquid reflectometer

BL04: Cold inelastic Spectrometer

BL06: molecular vibration Spectrometer

BL08A: neutron technology test station

BL10: Backscattering spectrometer



BL12: Neutron Physics

BL17: Quasi-elastic spectrometer

BL19: Single crystal diffractometer

BL20: Polarized chopper spectrometer

BL07: Reserve

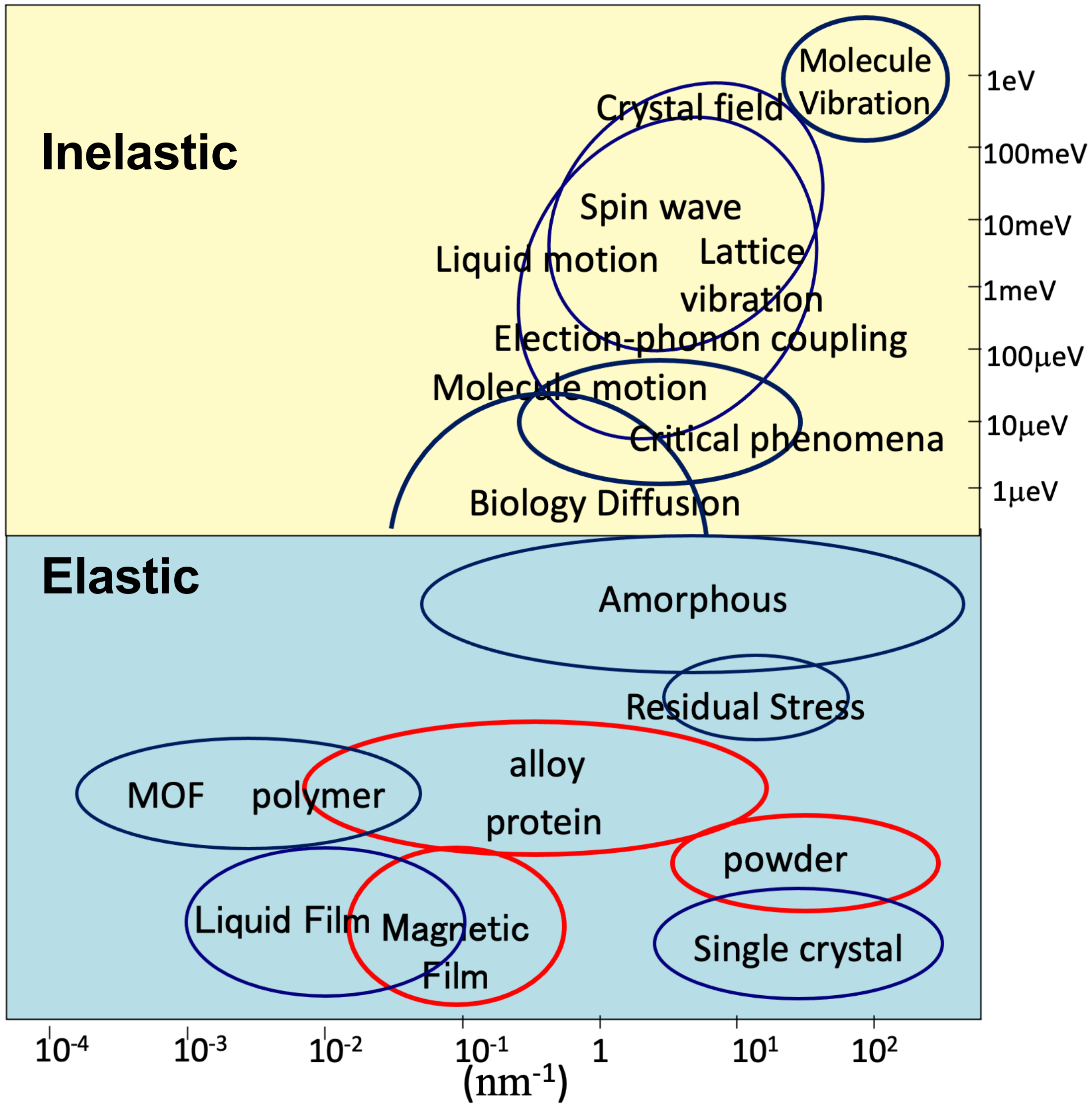
BL10A: Reserve

Extension of Application Fields

Application Area covered by Neutron instruments

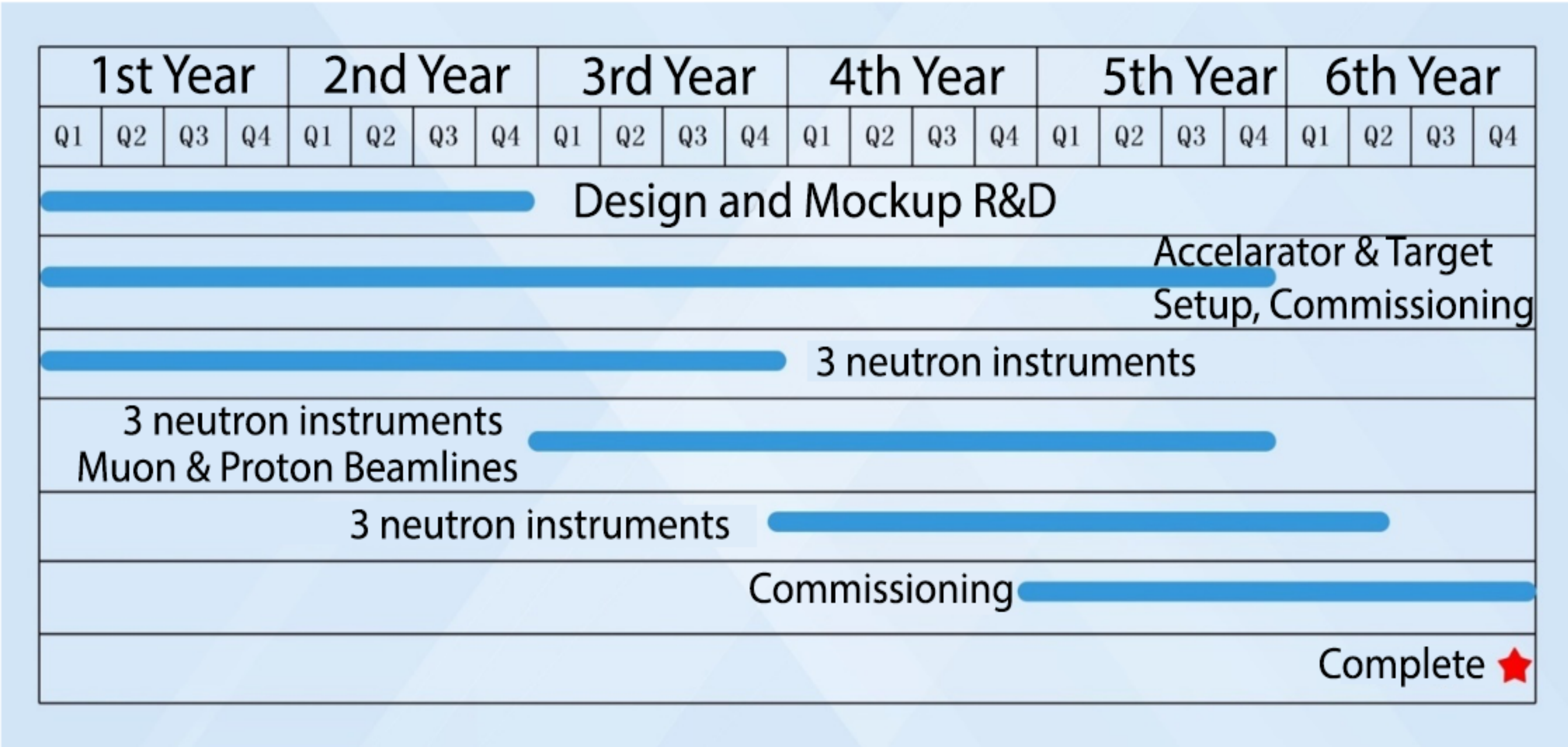
Phase I

Phase II



CSNS-II Schedule

- Construction duration: 6 years
- Keep user operation at least 3 months per year



Future

Summary

- CSNS passed the national acceptance on August 23, 2018, and was officially opened to users.
- The operation of CSNS goes well with high efficiency. The user demand is very strong.
- The design and construction of cooperation instruments are underway.
- The CSNS-II is expected to be started by the end of 2021, and will be completed by the end of 2027
- Collaboration about neutron , photon and muon is appreciated!

Thank you ！