China Spallation Neutron Source

Hesheng Chen

Institute of High Energy Physics, CAS

Outline

- **Inst. of High Energy Physics**
- **CSNS project overview**
- **CSNS design**
- **Commissioning & operation**
- **Users and future plan**
- **Summary**

Institute of High Energy Physics

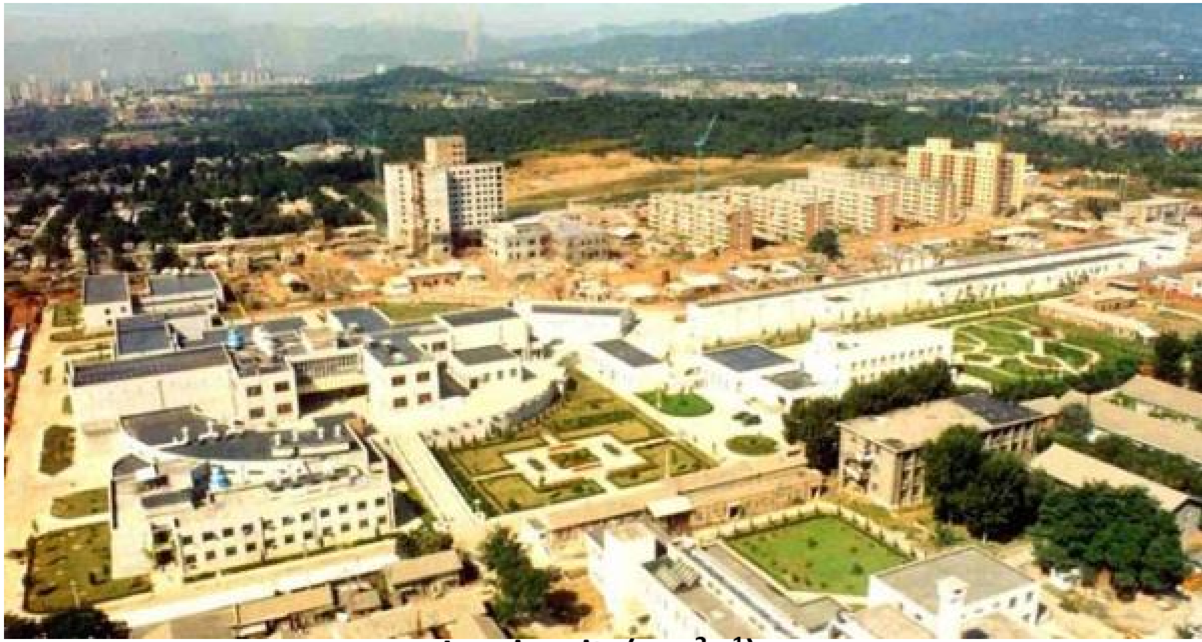
- Institute of Modern Physics: established at 1950
- Institute of High Energy Physics: independent Institute for Particle physics at 1973
  → Comprehensive and largest fundamental research center in China
  - 1600 employees, 3/4 of them: physicists and engineers
  - 550 PhD Students and 60 postdoctors
  - 400 visitors + Synchrotron Radiation users
- Mission of IHEP:
  - Particle physics center
  - Multiple discipline research center based on large scientific facilities.

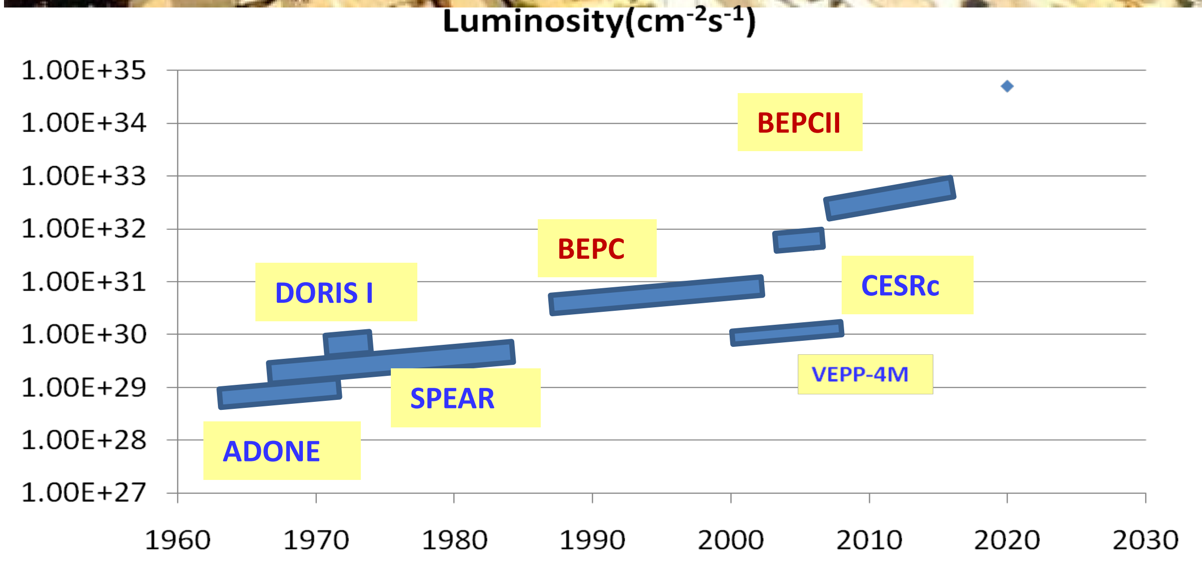
Major research fields at IHEP

- Particle physics:
  - Charm physics @ BEPC → CEPC ?
  - LHC exp. : CMS and Atlas, upgrade
  - Yangbajing cosmic ray observatory → LHAASO
  - particle astrophysics: Polar, HXMT, Ali → HERD
  - Neutrino physics: Daya Bay ν exp. → JUNO
- Accelerator technology and applications
  - High Lumi. e+e- collider: BEPCII
  - High power proton accelerator: CSNS, ADS
- Radiation technologies
  - Synchrotron radiation source and applications
  - Spallation neutron source and application
- Construction and operation of large scientific facilities
- Multiple discipline research: life science, nano-sciences, nuclear imaging, environment……

Beijing Electron-Positron Collider(BEPC)

- **The starting point of Particle Physics in China is the construction of BEPC in middle 80's**
- **Upgrade of BEPC (BEPCII) is completed in 2008. It leads IHEP to be one of the most active HEP centers in the world.**
- **The research of IHEP now covers particle physics, astrophysics , synchrotron radiation, spallation neutron source and their applications.**





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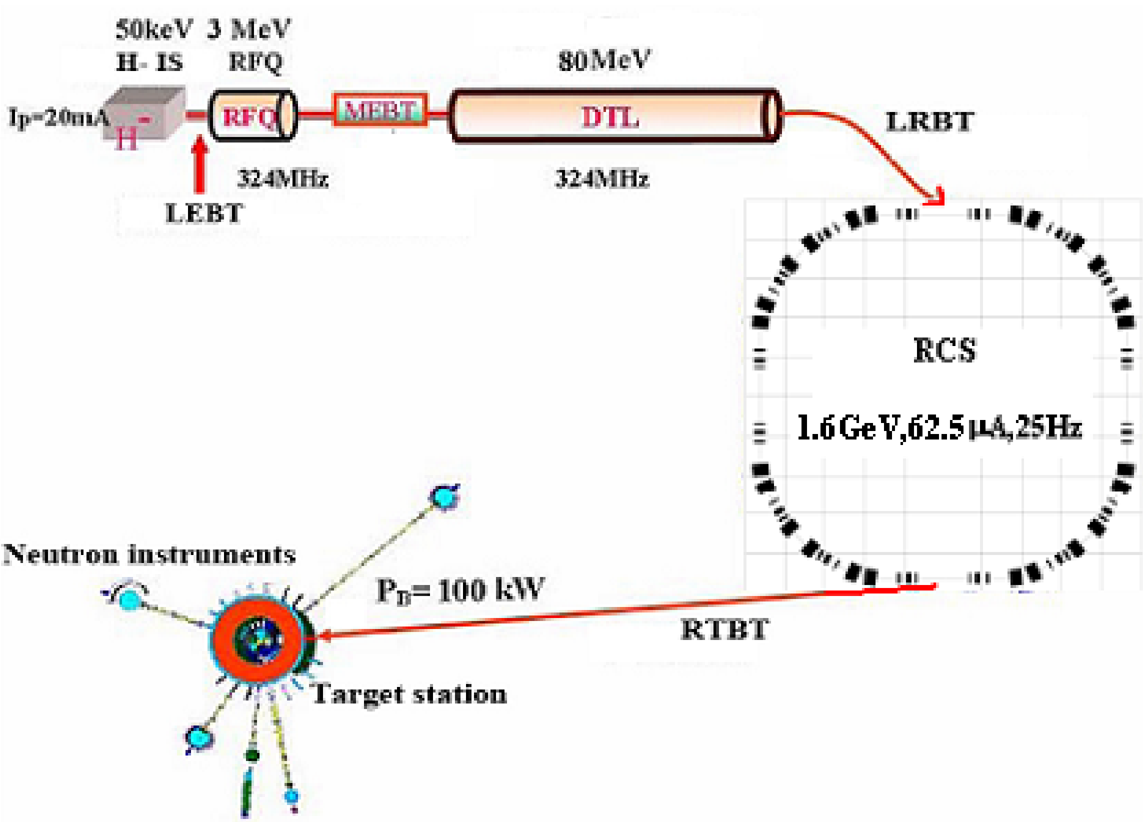
CSNS Facility Layout

- The phase-I CSNS facility consists of 80-MeV H^- linac, 1.6-GeV RCS, beam transport lines, target station, and 3 instruments.
- Upgradable to 500kW at 25Hz and 20 instruments
- Conducted jointly by IHEP & IOP, CAS



	CSNS-I	CSNS-II
Beam power (kW)	100	500
Repetition Rate (Hz)	25	25
# of Target	1	1
Average cur. (μA)	62.5	312
Proton energy(GeV)	1.6	1.6
Linac energy (MeV)	80	250

Key Milestones

July 1999	CSNS proposed
June 2005	proposal approved in principle (CD-0)
Jan. 2006-Dec. 2013	Prototyping R&D
Sept. 2008	Proposal approved
February 2011	Feasibility study approved (CD-1)
May 2011	preliminary design approved (CD-2)
Sept. 2011	construction start (CD-3)
May 2012 – Jan 2016	civil construction
Sept. 2011–Mar. 2016	component fabrication
Oct. 2014- June 2017	installation & tests
Dec. 2016	RCS commissioning start
Aug. 2017	First beam on target
March 2018	project complete/operation start (6.5Y)
April 2018	First user exp. result paper published
Aug. 2018	passed National acceptance

CSNS Site

- The site of CSNS locates at Dongguan, Guangdong Province.
- The Dongguan local government provided a land of about 0.67km^2 for CSNS campus. 0.27-km^2 is used for the phase-I construction.
- 50 min. by car from the Shenzhen Airport; 2 hours by train & car from Hongkong


中国散裂中子源装置地 2012年6月20日A点拍摄


中国散裂中子源工程进展照片（2017.12）

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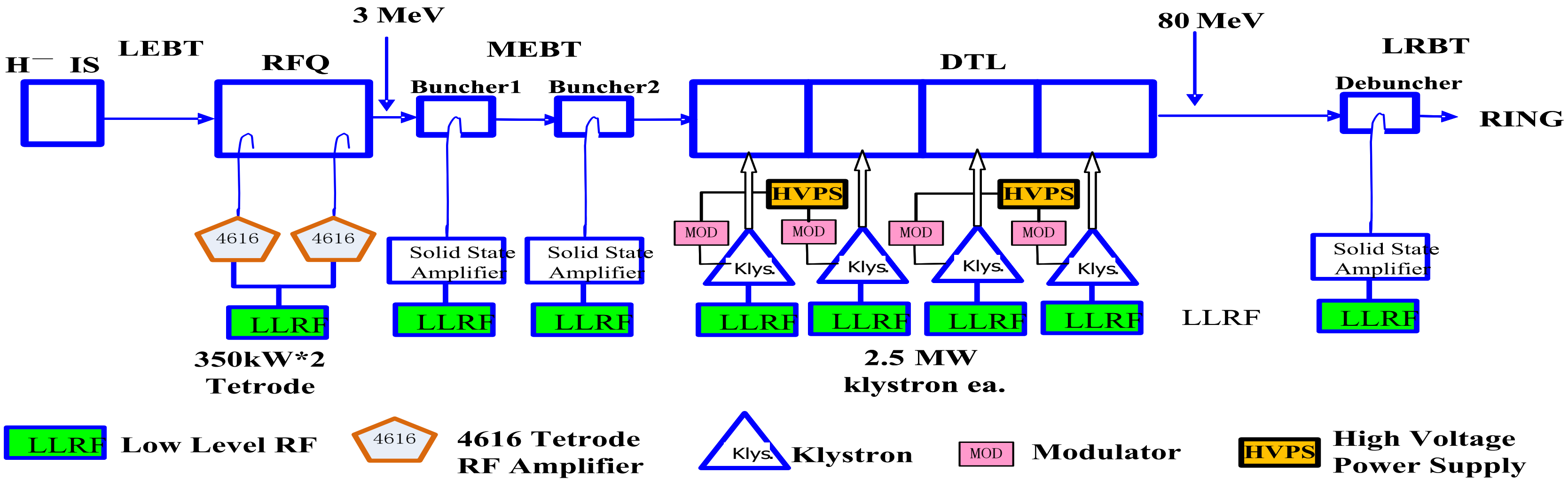
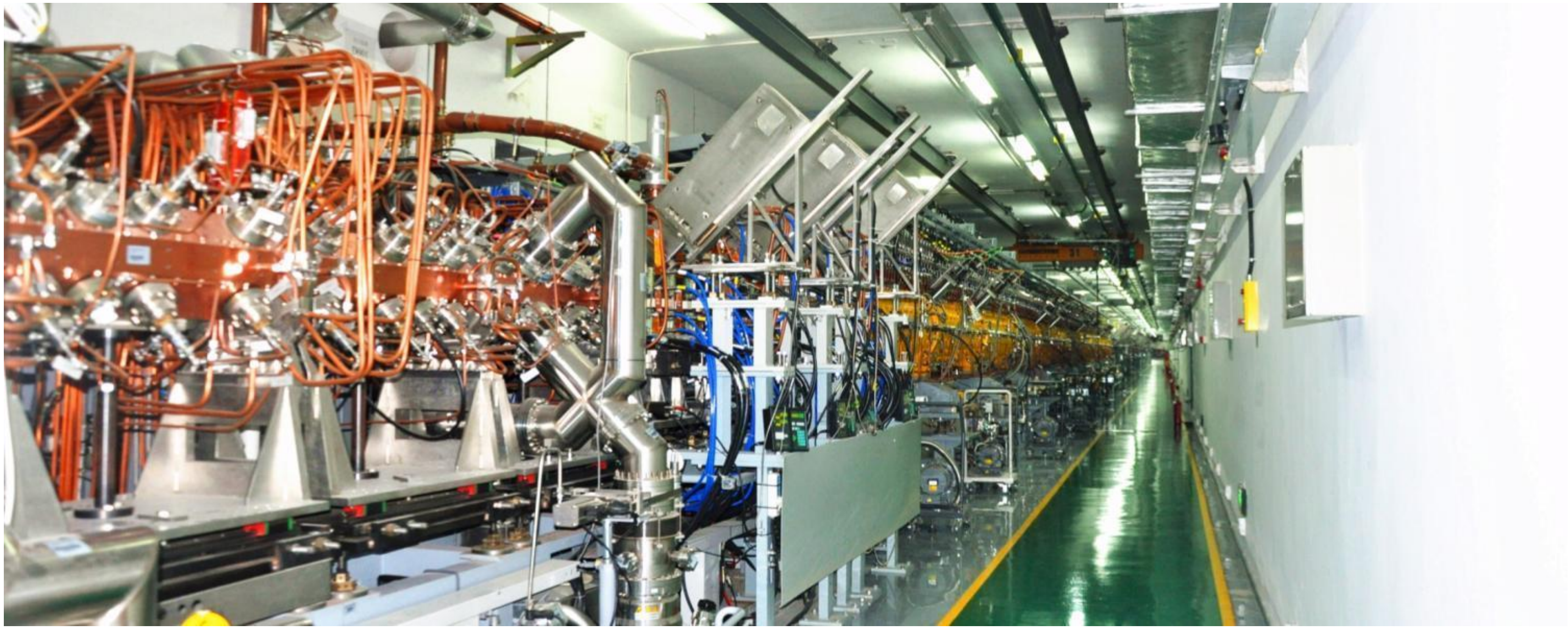
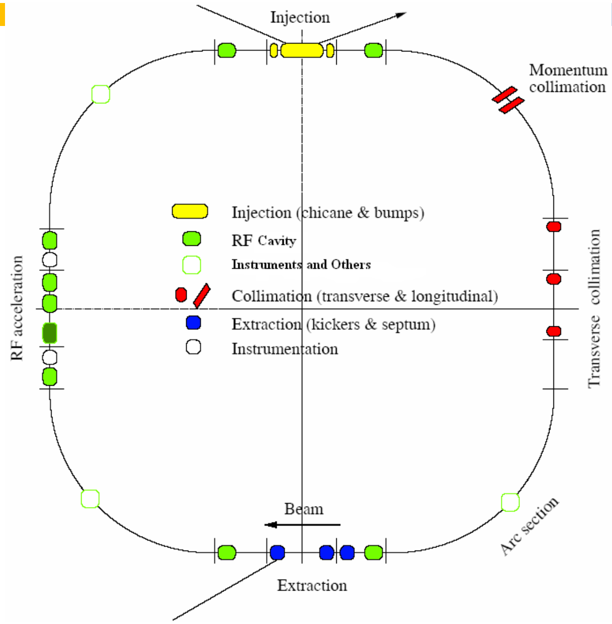
Linac Design

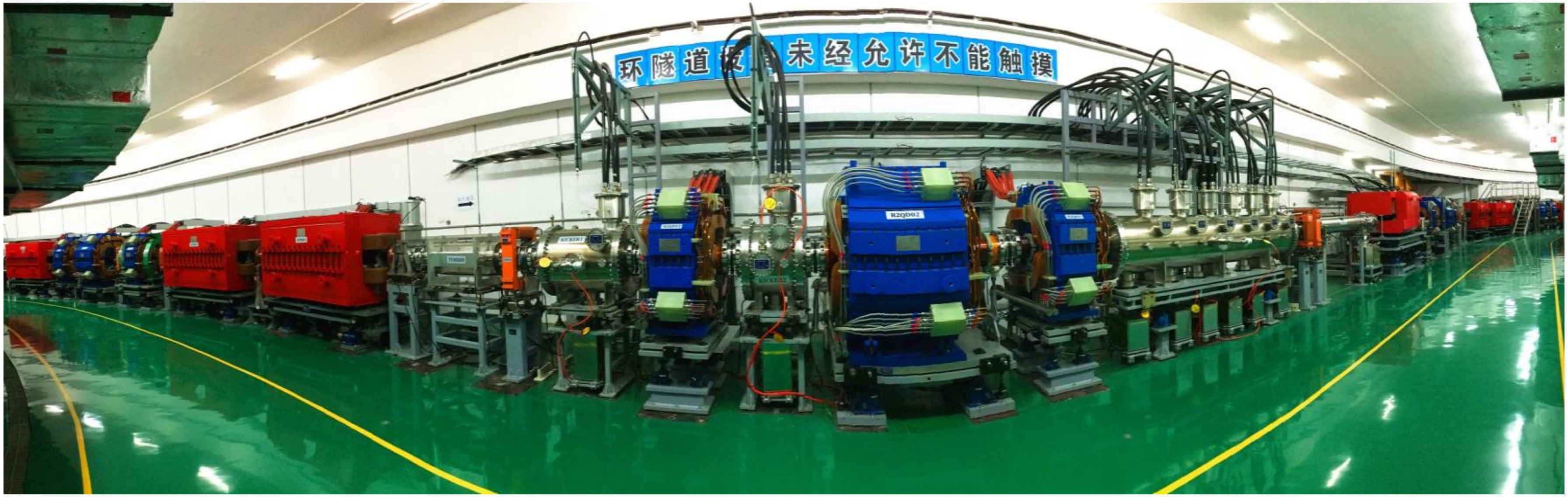




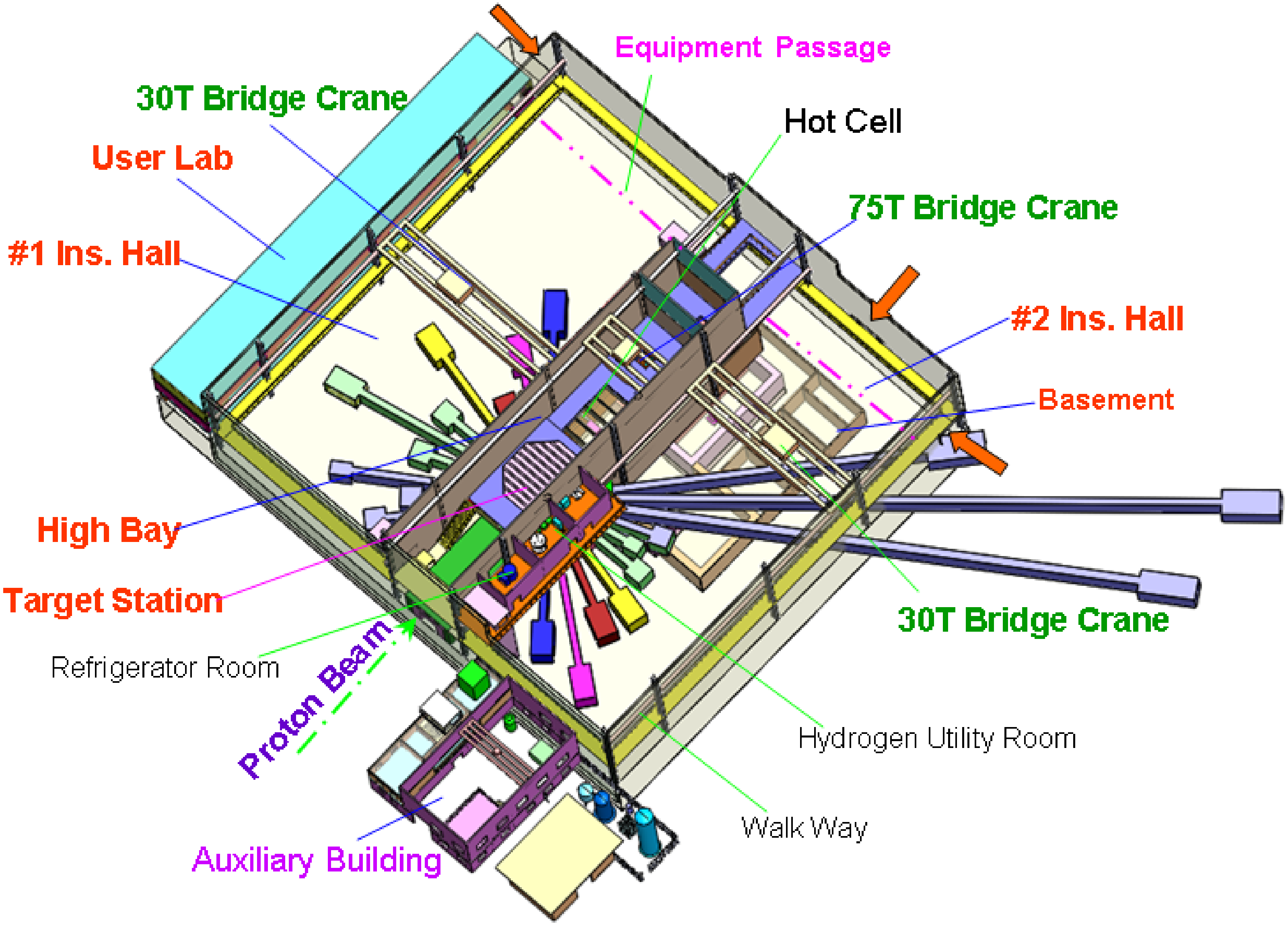
RCS Design

- Lattice of 4-fold symmetry, triplet.
- 227.92m circumference.
- Four long straight sections for injection, acceleration, collimation and extraction.
- 25Hz, 80~1600MeV

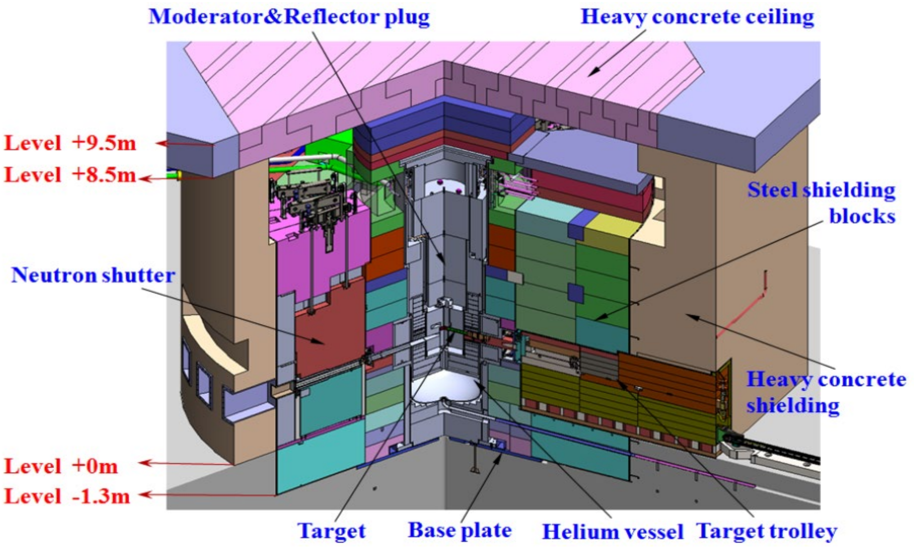


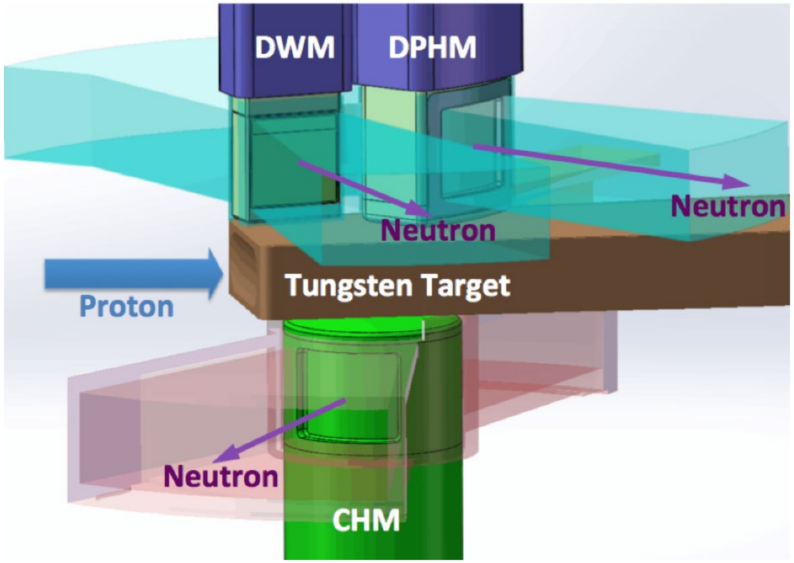


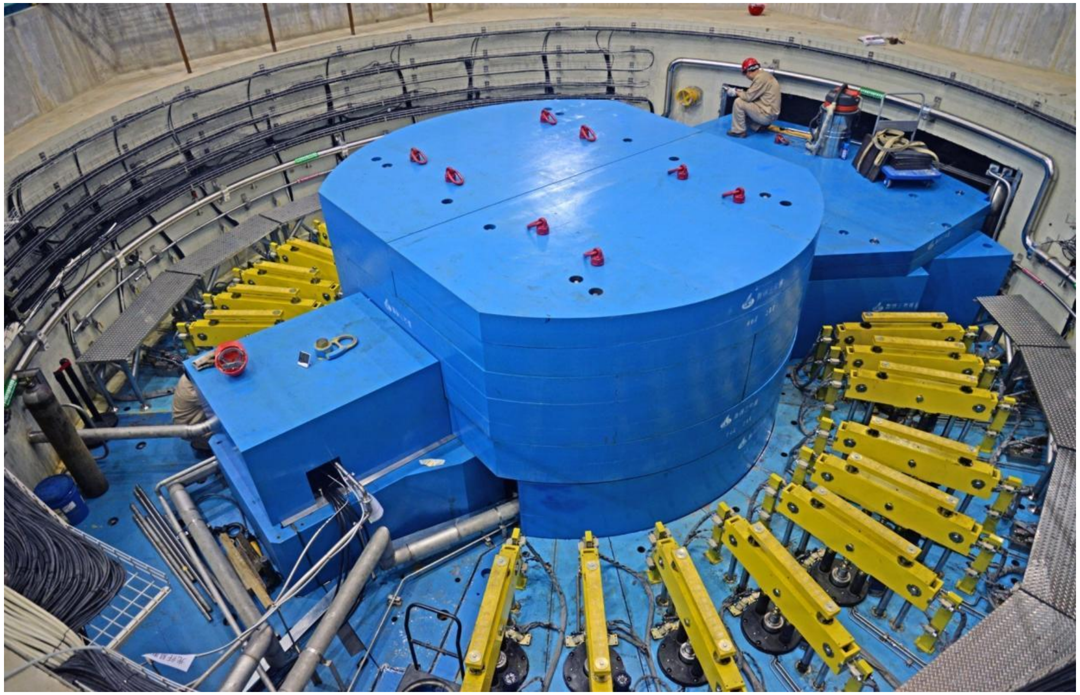
Neutron scattering hall



Target station



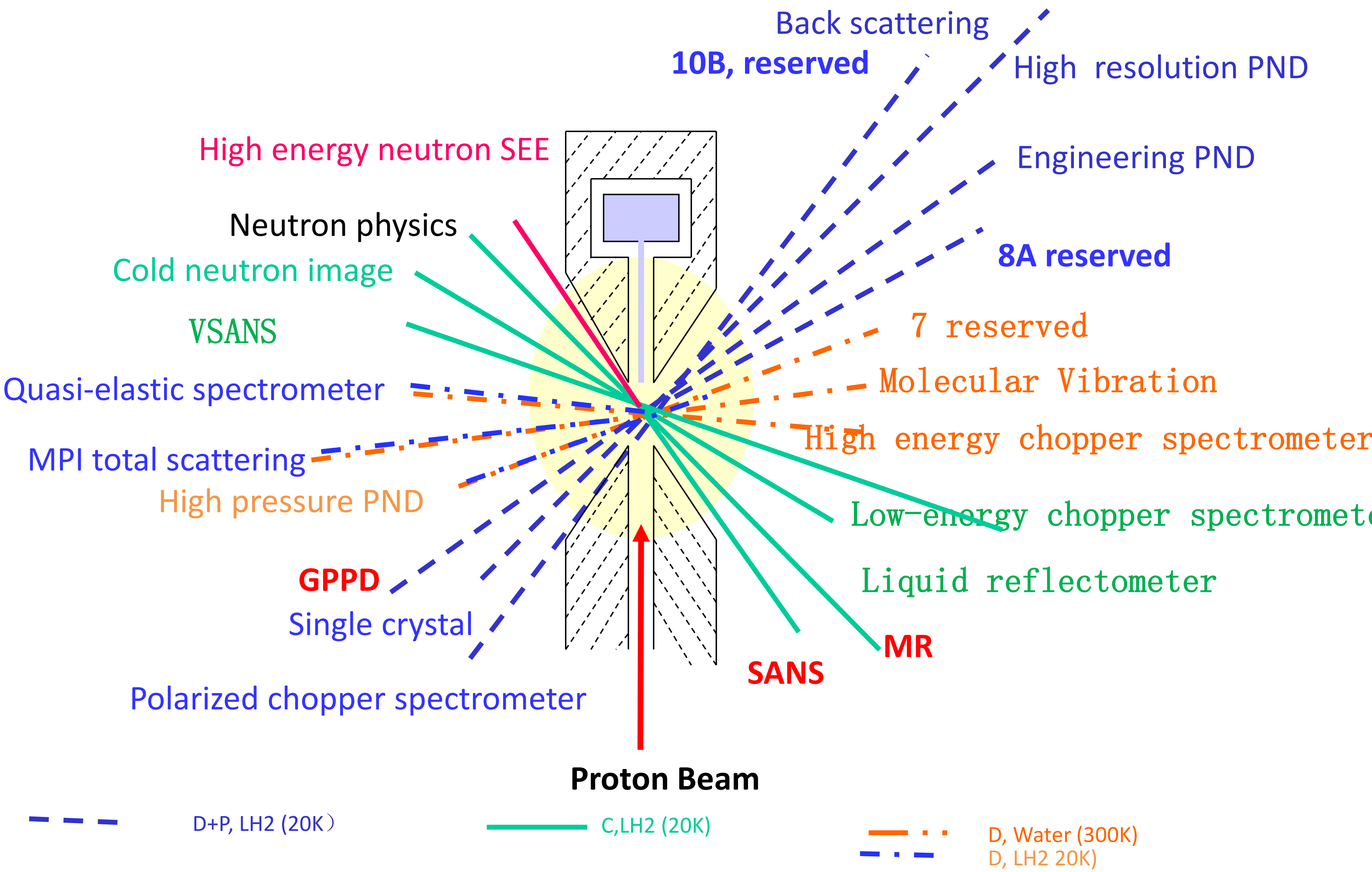




- water cooling Tungsten target
- Three modulators
  - CLH2 (20K)
  - D+P LH2 (20K)
  - D H2O (300K)

    → D LH2 (20K)

Neutron instruments layout



Neutron instrument: GPPD design

Performance:

- Determine crystallographic and magnetic structures in general purposes
- Best resolution Δd/d ~ 0.2 %.
- ~ 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

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

Neutron instruments: MR design

Performance:

- Vertical sample geometry: solid film
- Reflectivity/diffraction
- Best resolution ΔQ/Q < 1%
- Polarizing analysis for spinoelectronics.
- In-suit study on growing films
- In-suit MOKE magnetic analysis
- Off-specular scattering
- Grazing-incidence small-angle scattering

Moderator	CHM (20 K)
Bandwidth（Δλ）	6 Å
Guide	Bender+Sraight+Taper 40 × 60 → 20 × 30 mm²
SS distance L1	19.5 m
SD distance L2	2 m
Sample table	6-axis movements
Polarizer/analyzer	Supermirror type
Detector	2D position-sensitive resolution: 2 mm

Neutron instruments: SANS design

Performance:

- **Reliable SANS data between 0.01 ~ 0.5 Å^{-1} to characterize 1-100 nm particles.**
- **Instrument resolution better than ~30% around Q_{min}**
- **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}

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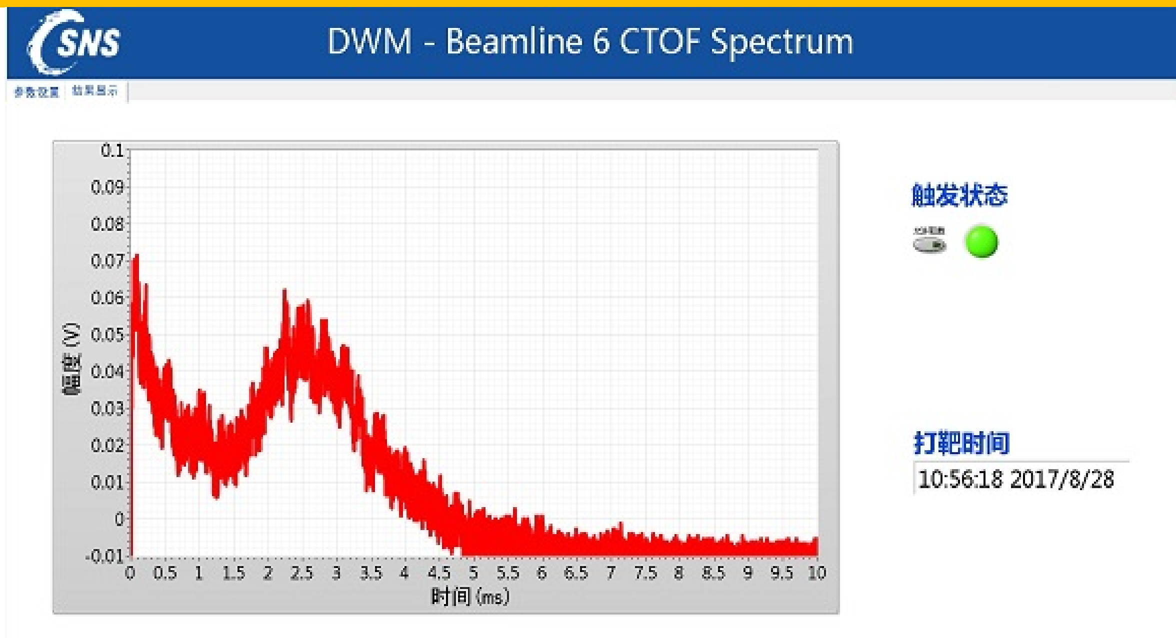
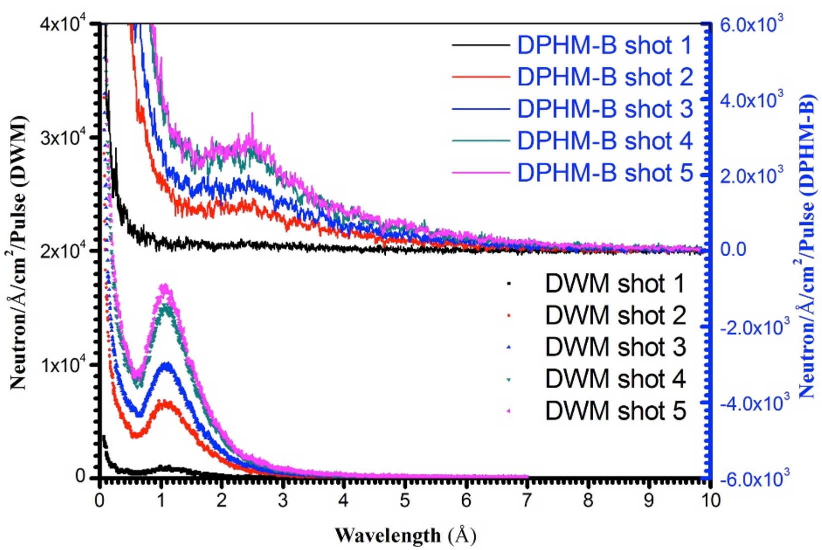
Birds View of CSNS
August, 2017

First Neutron @ Aug. 28, 2017





Design and Acceptance Goal

Design goal

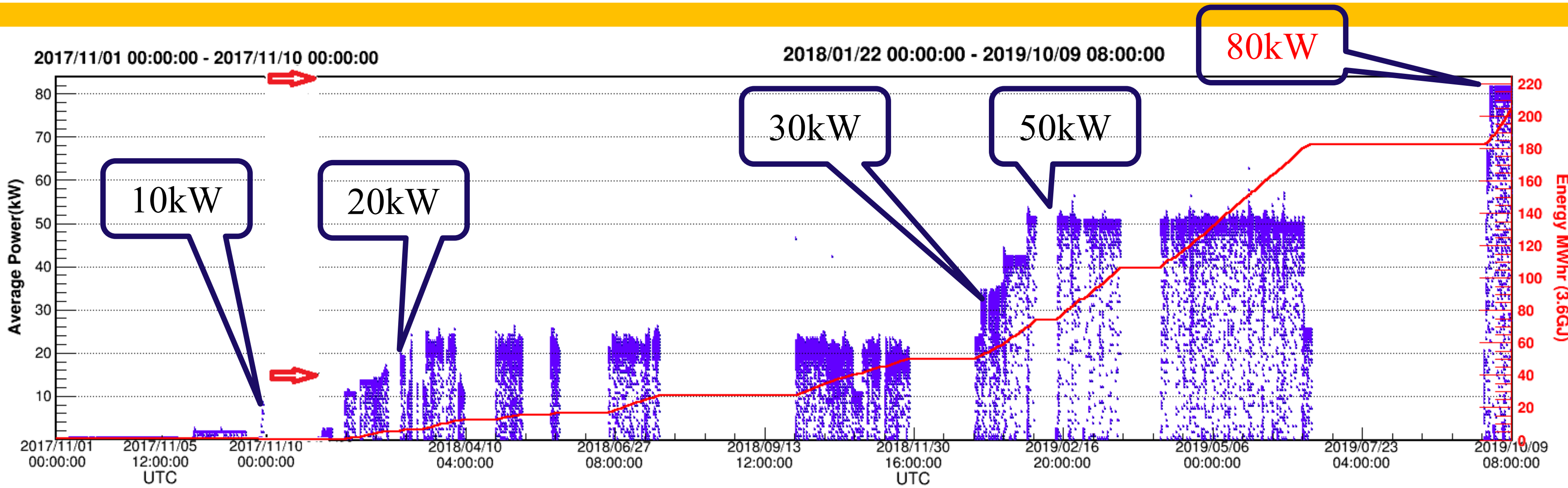
Beam power	Rep. rate	Ave. Curr.	Beam Energy	Neutron Efficiency	Neutron Flux
100 kW	25Hz	63μA	1.6GeV	0.1(n/p/sr)	$2*10^7$

Acceptance goal

Beam power	Rep. rate	Ave. Curr.	Beam Energy	Neutron Efficiency	Neutron Flux
10 kW	25Hz	6.3μA	1.6GeV	0.005(n/p/sr)	10^5
23 kW	**25Hz**	**14.5μA**	**1.6GeV**	**0.125**	**$2.5*10^6$**

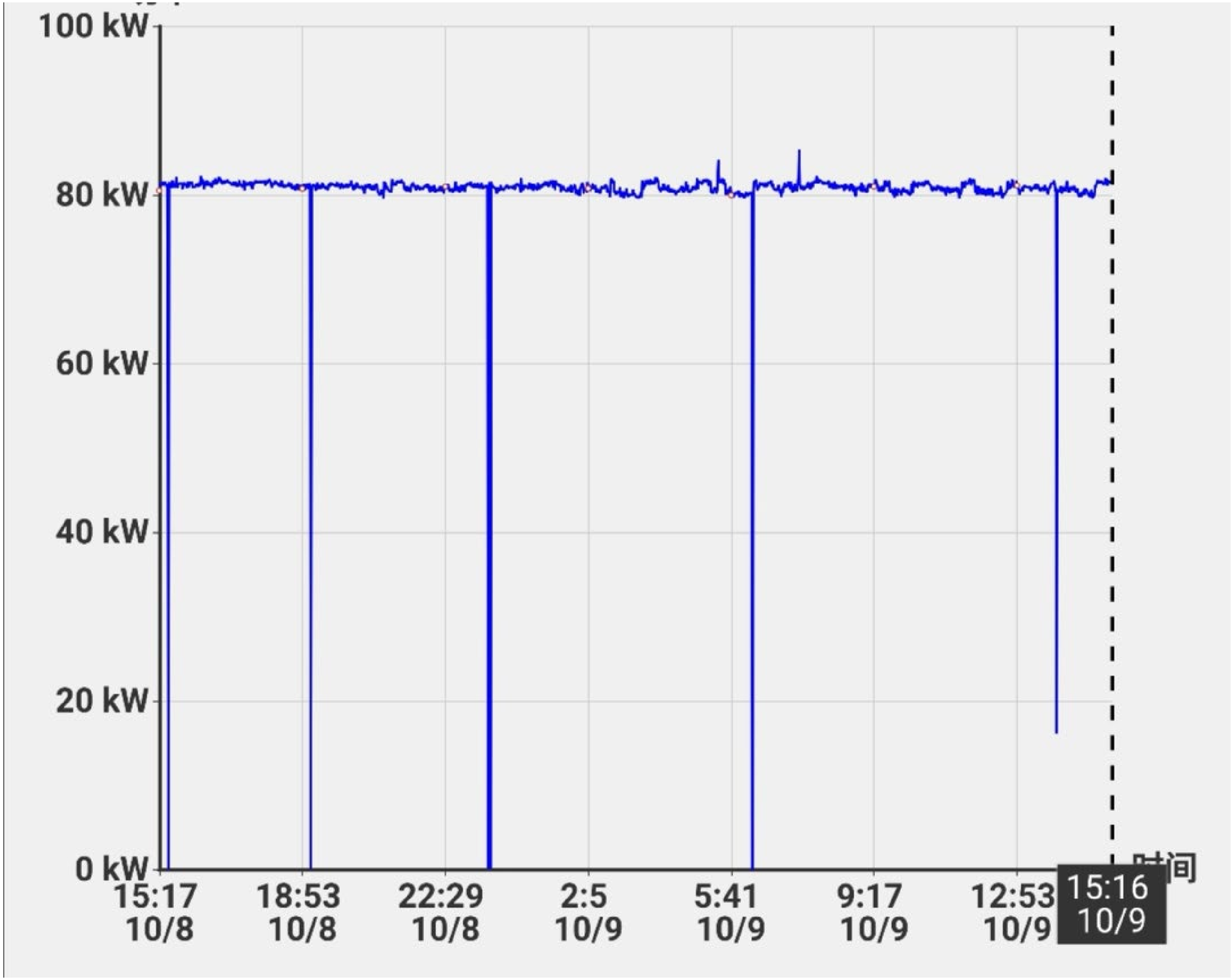
- In the technical test for official acceptance, all the acceptance goals have been reached, and most of them were exceeded.
- On construction schedule!

Historical curve of beam power



- ✧ Nov. 2017, First 10kW beam strike on target for a short while;
- ✧ Mar. 2018, beam power over 20 kW in the test operation;
- ✧ Jan. 2019, after 4 weeks beam commissioning , beam power was gradually increased to 50kW+ with well controlled beam loss.
- ✧ Sep. 2019, based on the 6 weeks beam commissioning, the beam power in user operation was increased to 80 kW step by step.
- ✧ We plan to increase the beam power to 100kW by the first half of 2020.

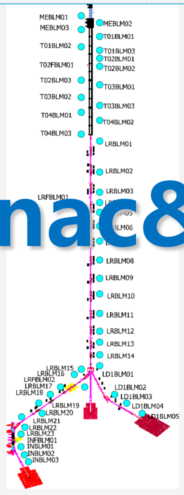
24 hours beam operation (Oct.8,2018)



Beam loss and control

Linac&LRBT

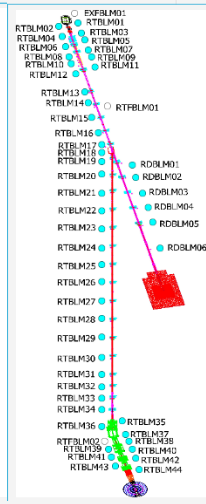
2019/05/03 05:00:00



MEBLM01	-2895.43	LRBLM09	10.61
MEBLM02	40.17	LRBLM10	-2.19
MEBLM03	43.52	LRBLM11	4.37
T01BLM01	0.94	LRBLM12	-3.44
T01BLM02	-0	LRBLM13	-4.06
T01BLM03	127.19	LRBLM14	-0.62
T02BLM01	12.5	LD1BLM02	18.75
T02BLM02	6.88	LD1BLM01	2.19
[illegible]	[illegible]	LRBLM15	1.25
[illegible]	[illegible]	LRBLM16	-16.25
[illegible]	[illegible]	LRBLM17	19.68
T03BLM03	-4.69	LRBLM18	12.81
T04BLM01	93.45	LRBLM19	21.26
T04BLM02	38.12	LRBLM20	-0.62
T04BLM03	19.7	LRBLM21	15.62
LRBLM01	6.87	LRBLM22	7.81
LRBLM02	7.5	LRBLM23	130.27
LRBLM03	-4.37	INDBLM01	1.88
LRBLM04	4.69	INDBLM02	2.19
LRBLM05	18.44	INDBLM03	4.69
LRBLM06	-0.94	LD1BLM03	16.88
LRBLM07	-9.68	LD1BLM04	10.93
LRBLM08	9.68	LD1BLM05	22.5

RTBT

2019/05/03 05:00:00

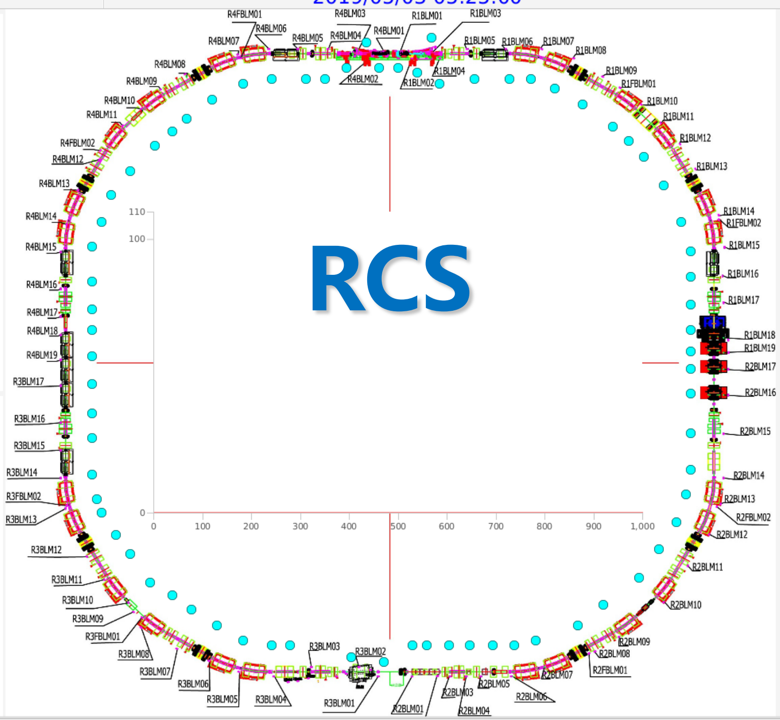


RTBLM01	6.87	RTBLM26	6.25
RTBLM02	10	RTBLM27	5.62
RTBLM03	[illegible]	RTBLM28	5.63
RTBLM04	[illegible]	RTBLM29	5.94
RTBLM05	[illegible]	RTBLM30	6.88
RTBLM06	4.68	RTBLM31	10.62
RTBLM07	5	RTBLM32	6.24
RTBLM08	5.94	RTBLM33	10.31
RTBLM09	263.14	RTBLM34	7.81
RTBLM10	100.95	RTBLM35	8.13
RTBLM11	6.25	RTBLM36	9.37
RTBLM12	128.04	RTBLM37	68.13
RTBLM13	98.1	RTBLM38	95.64
RTBLM14	93.43	RTBLM39	171.24
RTBLM15	154.96	RTBLM40	351.65
RTBLM16	345.94	RTBLM41	231.77
RTBLM17	17.8	RTBLM42	325.88
RTBLM18	5.63	RTBLM43	695.53
RTBLM19	7.19	RTBLM44	503.7
RTBLM20	6.25	RDBLM01	7.81
RTBLM21	8.75	RDBLM02	10
RTBLM22	10.94	RDBLM03	4.69
RTBLM23	8.12	RDBLM04	6.25
RTBLM24	11.88	RDBLM05	66.54
RTBLM25	9.06	RDBLM06	5.31

RCS

Waveform Display | Show All Wav...

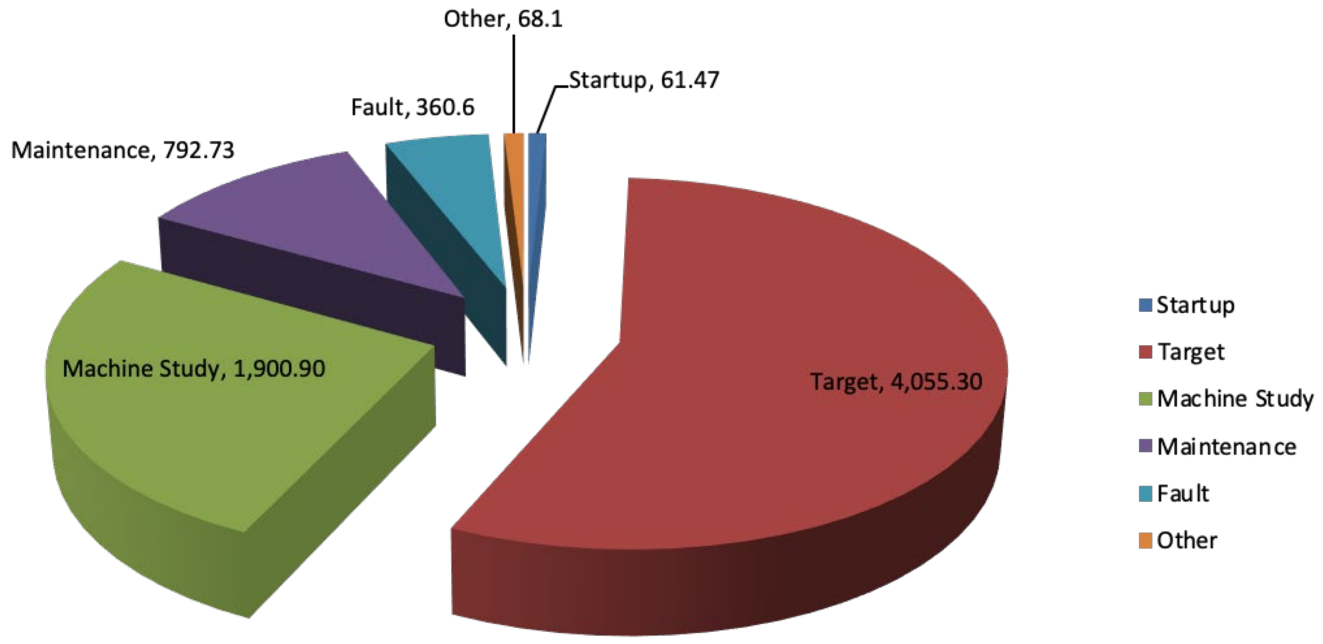
2019/05/03 05:25:00



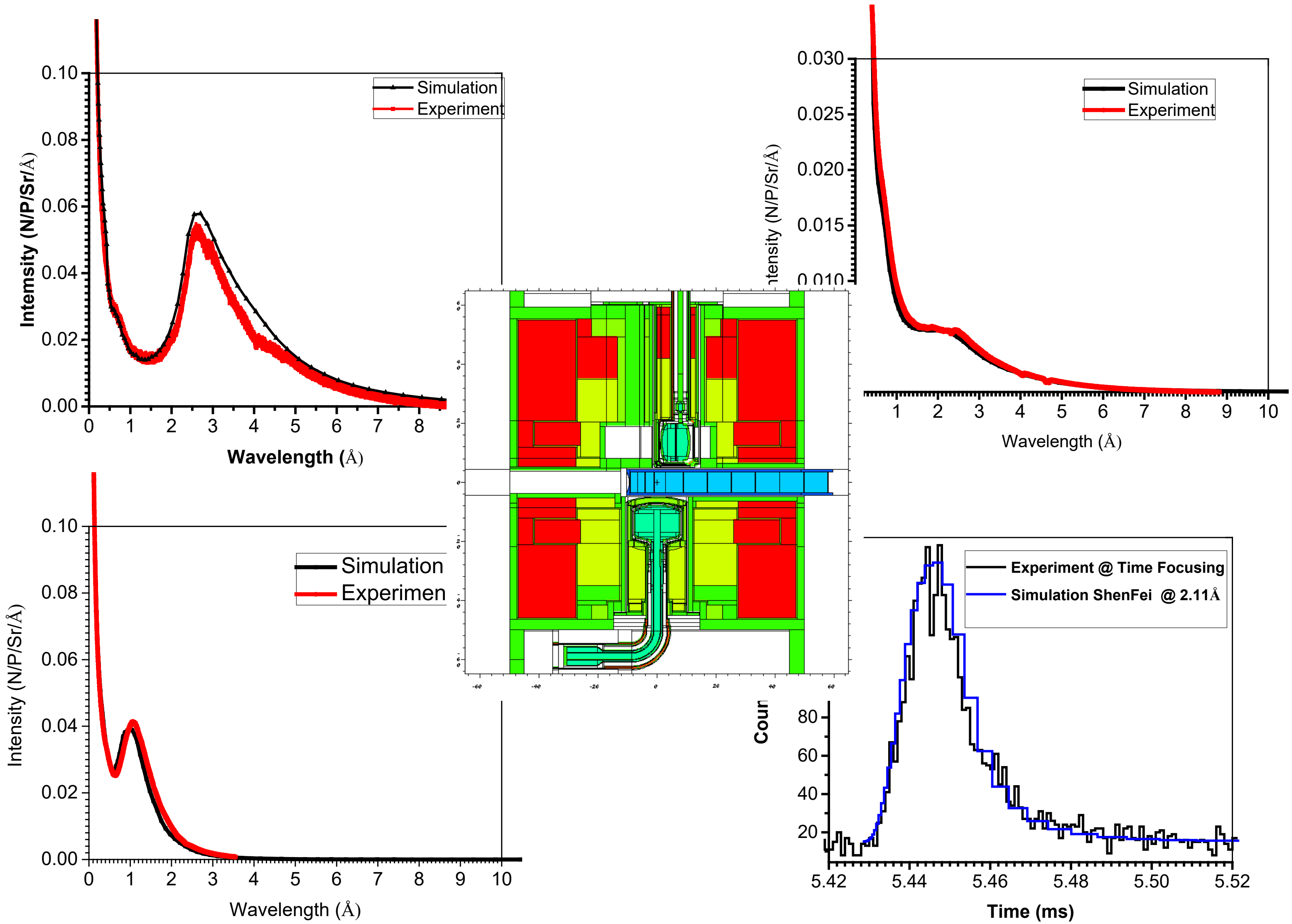
R4BLM01	640.24	R1BLM01	164.04
R4BLM02	119.39	R1BLM02	118.81
R4BLM03	97.52	R1BLM03	170.38
R4BLM04	82.5	R1BLM04	42.5
R4BLM05	101.21	R1BLM05	210.84
R4BLM06	97.22	R1BLM06	96.23
R4BLM07	164.03	R1BLM07	68.68
R4BLM08	264.23	R1BLM08	73.09
R4BLM09	121.56	R1BLM09	91.87
R4BLM10	125.36	R1BLM10	32.82
R4BLM11	164.68	R1BLM11	34.98
R4BLM12	98.16	R1BLM12	36.89
R4BLM13	211.12	R1BLM13	105.61
R4BLM14	182.68	R1BLM14	29.36
R4BLM15	232.96	R1BLM15	35.3
R4BLM16	77.76	R1BLM16	44.99
R4BLM17	164.33	R1BLM17	126.57
R4BLM18	117.85	R1BLM18	2.81
R4BLM19	121.87	R1BLM19	11.57
R3BLM17	45.01	R2BLM17	43.42
R3BLM16	64.03	R2BLM16	61.54
R3BLM15	88.39	R2BLM15	869.78
R3BLM14	55.29	R2BLM14	782.45
R3BLM13	58.12	R2BLM13	85.33
R3BLM12	54.36	R2BLM12	133.74
R3BLM11	56.23	R2BLM11	69.71
R3BLM10	51.26	R2BLM10	194.31
R3BLM09	26.88	R2BLM09	110.02
R3BLM08	54.98	R2BLM08	158.71
R3BLM07	37.18	R2BLM07	221.88
R3BLM06	50.32	R2BLM06	79.97
R3BLM05	84.65	R2BLM05	614.39
R3BLM04	50.93	R2BLM04	491.58
R3BLM03	62.51	R2BLM03	359.86
R3BLM02	71.56	R2BLM02	238.17

Machine hours Statistics (18.10-19.6)

- 4055 hours was provided to users in the first user operation
- The availability is over 92% during the user operation

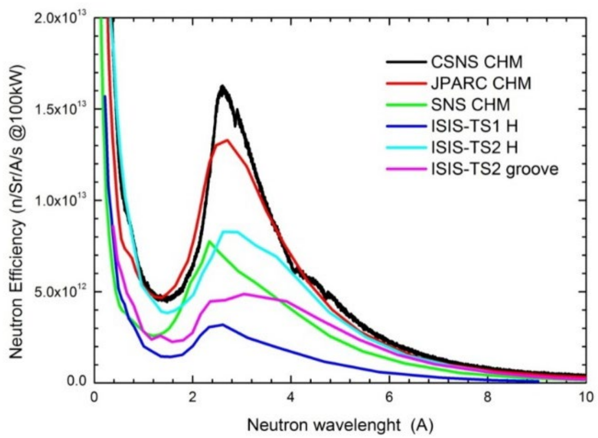


Neutronics Performance of Target Station

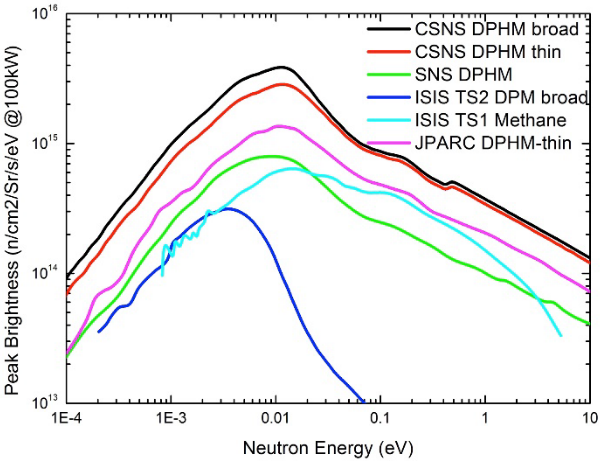


- **Measured spectra & pulse shape agreed well with simulation.**

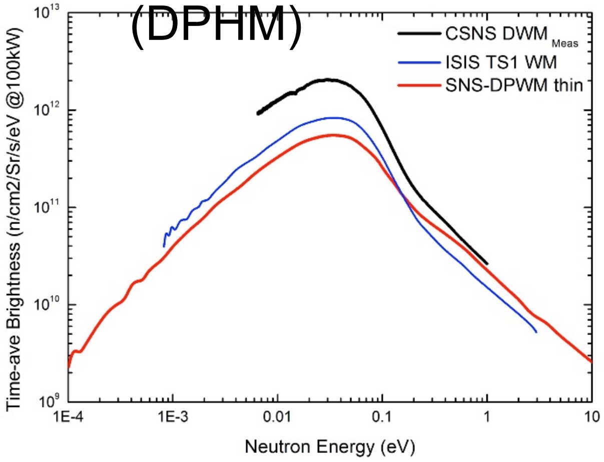
Neutronics Performance of Target Station



Wavelength spectra (CHM)



Peak brightness (DPHM)

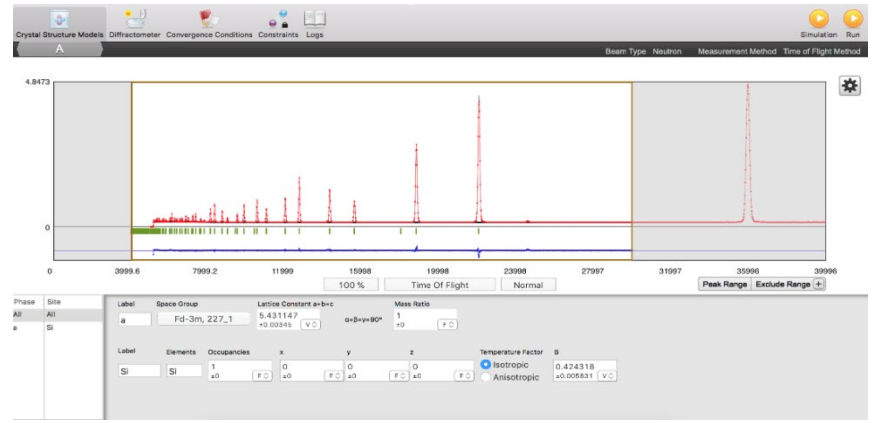


TAV brightness (DWM)

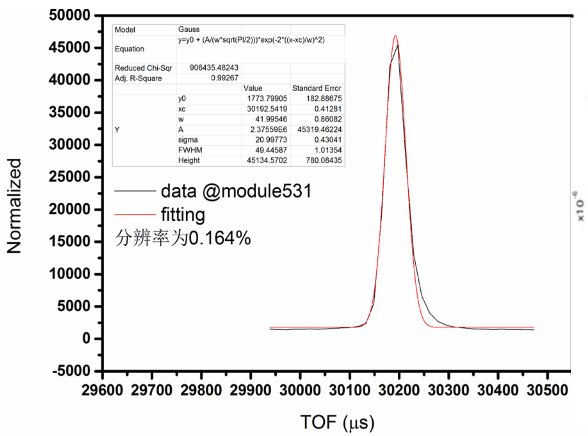
The neutronic performance of the source (and moderators) is excellent, and provides evidence of strong coupling between the target and the moderators.

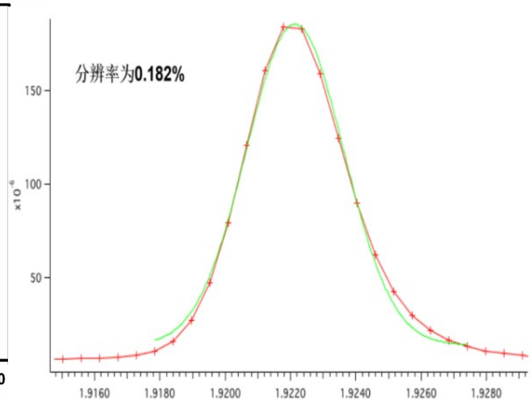
NTAC10 report, Dec, 2018

Commissioning of GPPD



NIST-640e standard sample Si, refinement Rp = 1.88%、 Rwp= 2.89%





GPPD can obtain accurate and reliable information on the determination of crystal structure and magnetic ordered structure, the discrimination of light elements and adjacent transition elements and so on.

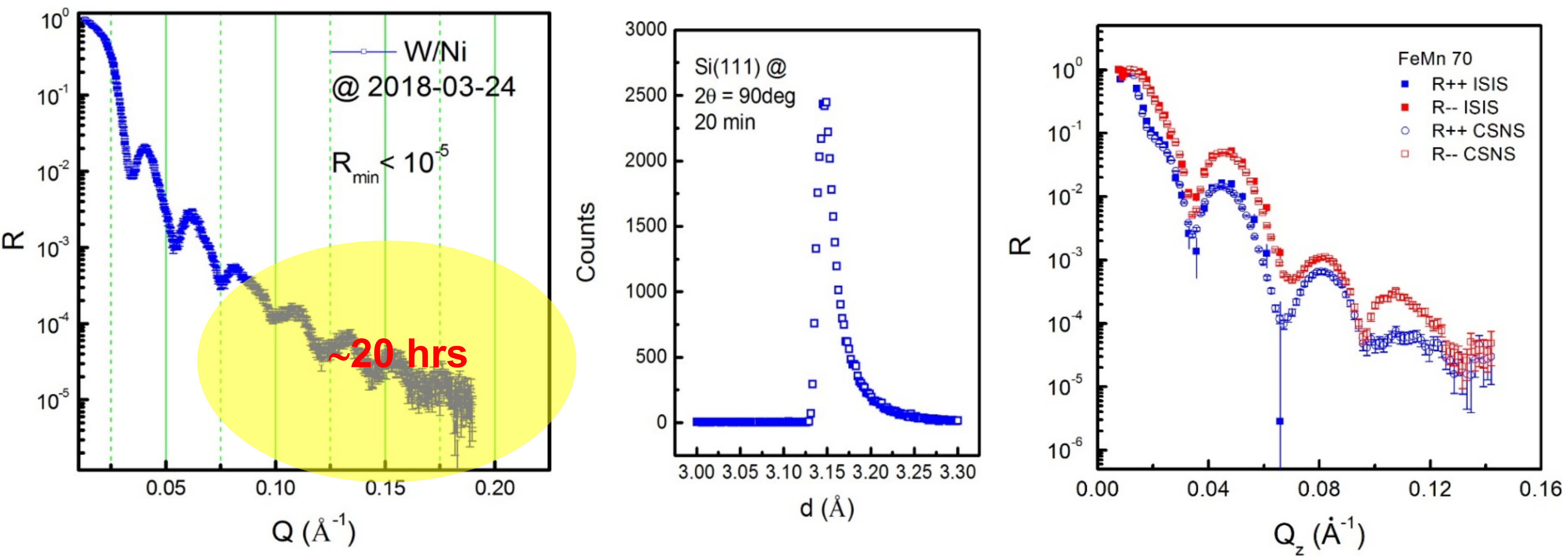
0.164% for one module @ back scattering

0.182% for back scattering bank

GPPD review committee, April, 2018

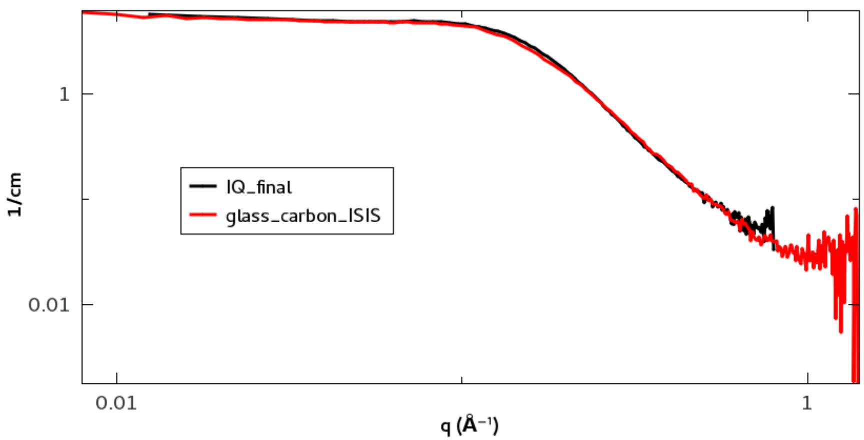
Better than the design goal

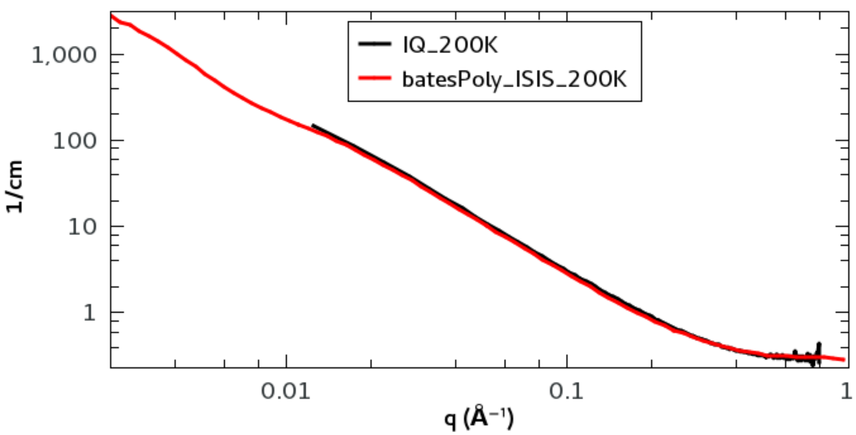
Commissioning of MR



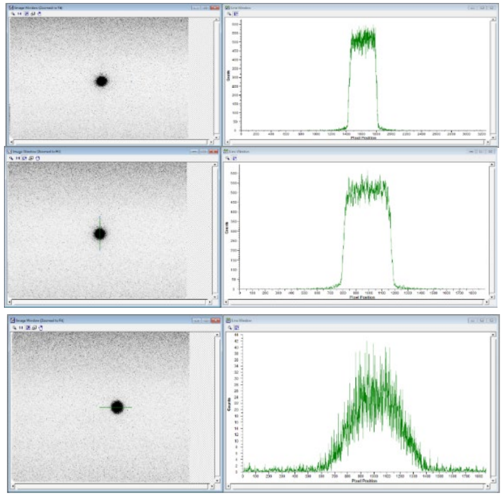
Function NR： $R_{min}<10^{-5}$ **Diffraction:** $\Delta d/d = 0.6\%$ **PNR:** done

Commissioning of SANS

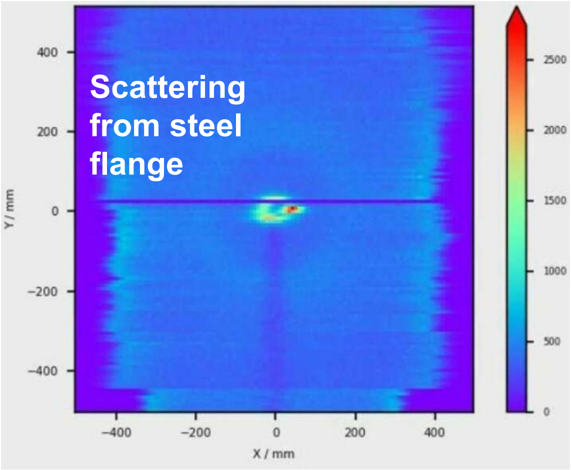




Glass carbon & Bates-poly，molecular weight: 200 k



Beam size diagnostic



Background analysis

GPPD: Li-ion batteries research

Li/Ni exchange ratios in series of $LiNi_xMn_yCo_zO2$ materials are precisely determined for the first time

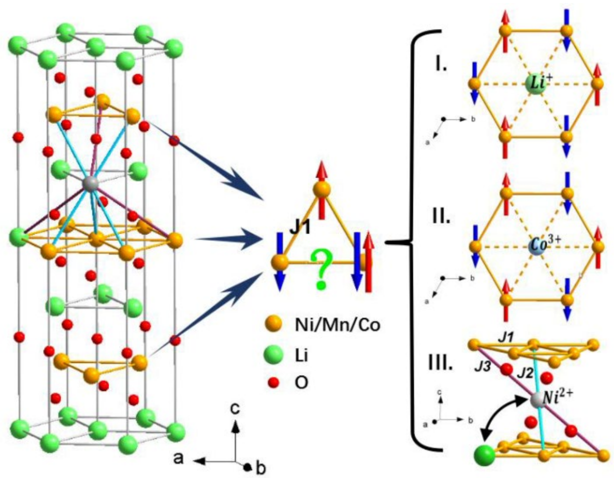
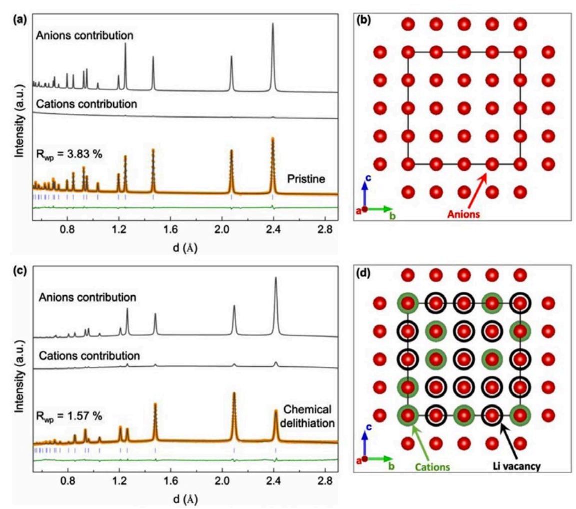


Illustration of a pair of Li/Ni exchange and arrangement of magnetic moments in the TM layer of triangular lattice

Y.G. Xiao et al. *Nano Energy* 2018, 49, 77–85

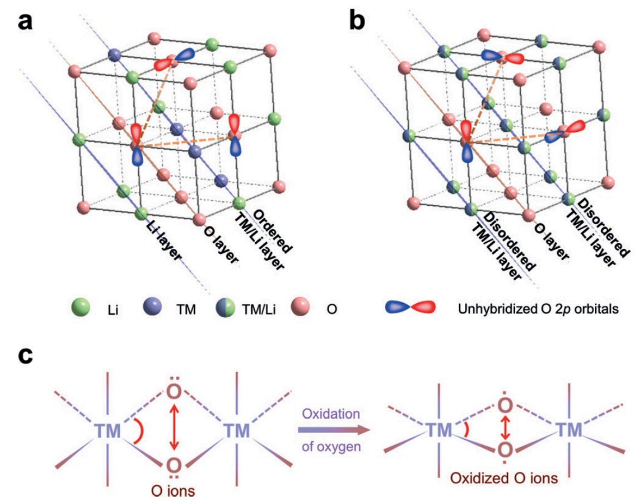
The superior structure stability and robust anions framework of LTNNbOF (280 mAh/g) upon (de)lithiation process were experimentally demonstrated.



Rietveld refinement of the NPD patterns and calculated cations/anions diffraction patterns for the pristine and the corresponding schematic crystal structure.

E.Y. Zhao et al. *Energy Storage Materials* 2019, 16, 354–363

The structural-dimensionality effect on the l-OR and associated oxygen lattice stability in Li-rich cathodes have been characterized and clarified.

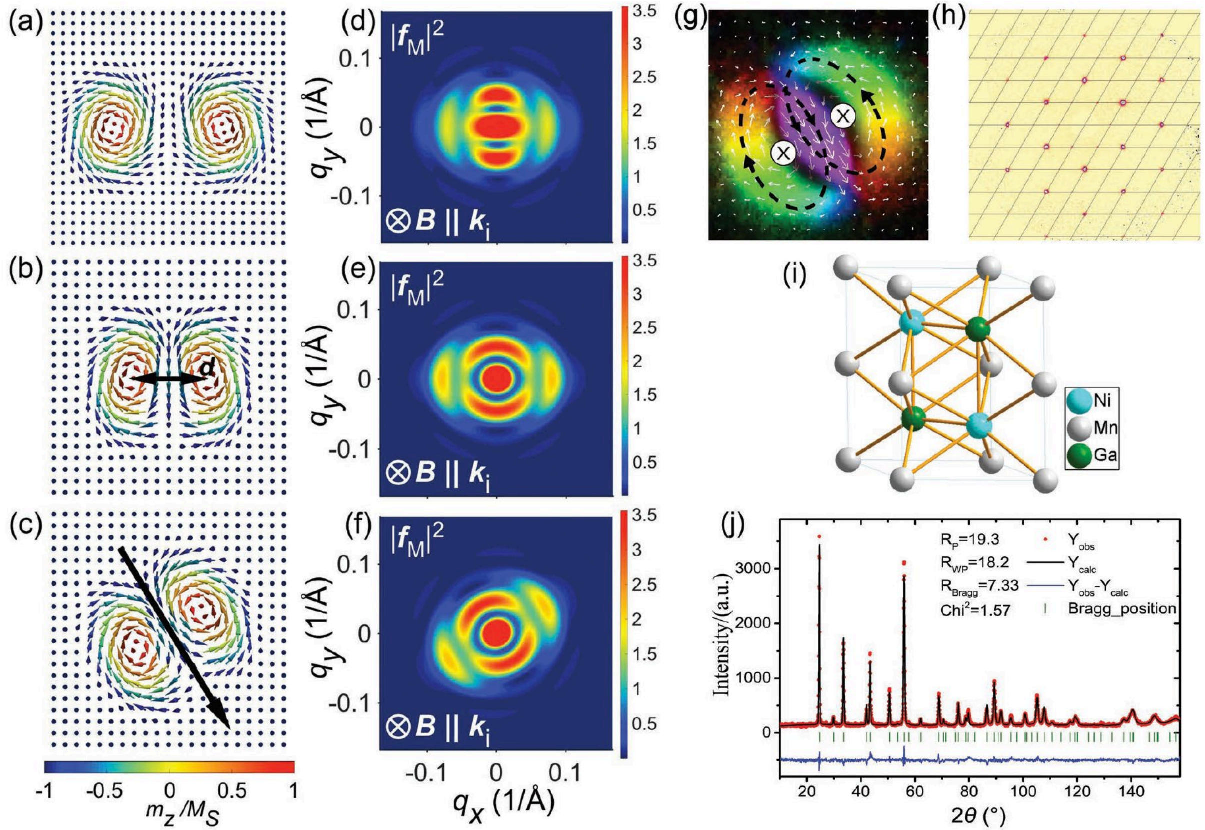


a) 2D-ordered cation layer; b) 3D-disordered cation framework; c) Schematic representation of the shrinking distance between a pair of O–O ions and the corresponding structure distortion.

E.Y. Zhao et al. *Angew. Chem. Int. Ed.* 2019, 58, 1–6

GPPD: Magnetic skyrmions research

The structural parameters of the biskyrmion state in MnNiGa bulk crystals was determined



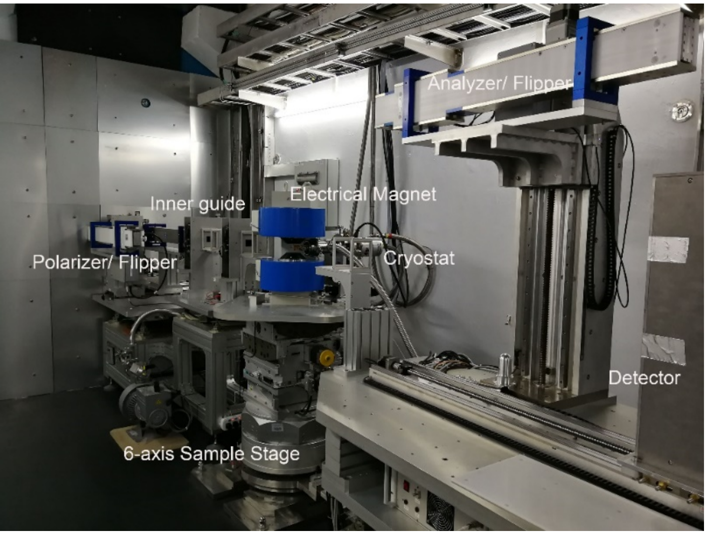
a–c) Structural parameters describing a C2v biskyrmion; d–f) The simulated magnetic form factors corresponding to (a–c), respectively; g) An in-plane magnetization of the biskyrmion configuration. h) The MnNiGa single-crystalline sample is checked using a single-crystal X-ray diffractometer; i,j) The refinement result of high-resolution neutron powder diffraction data.

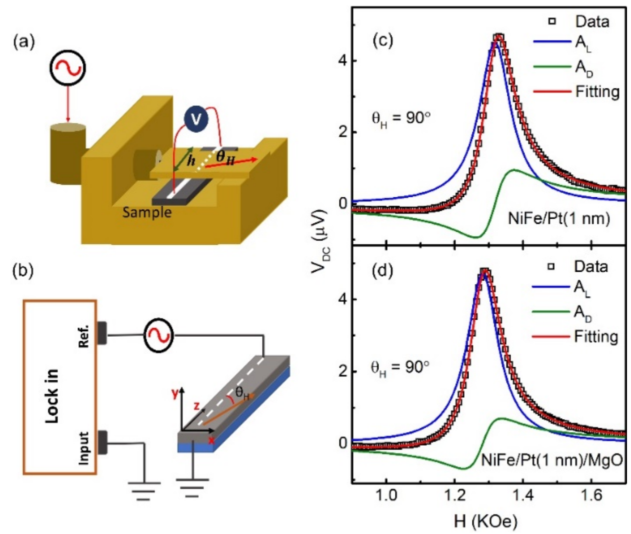
X.Y. Li, et al. *Adv. Mater.* 2019, 1900264

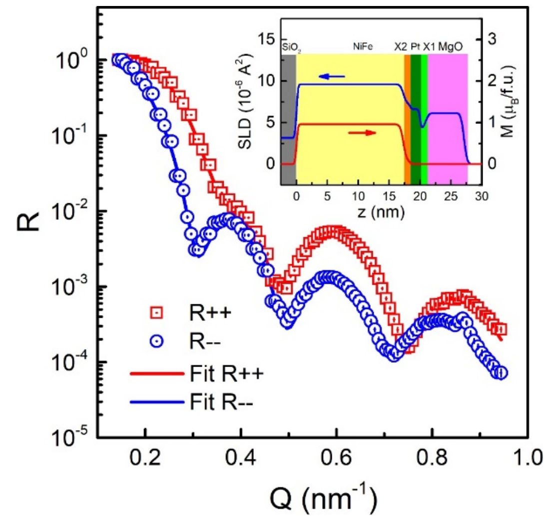
MR: Multipurpose Reflectometer

Interface Induced Enhancement of Inverse Spin Hall Voltage in NiFe/Pt Bilayers Capped by MgO layer

Probe the deep inside a film







Zhu et al 2018 *Neutron News*, 29(2), 11

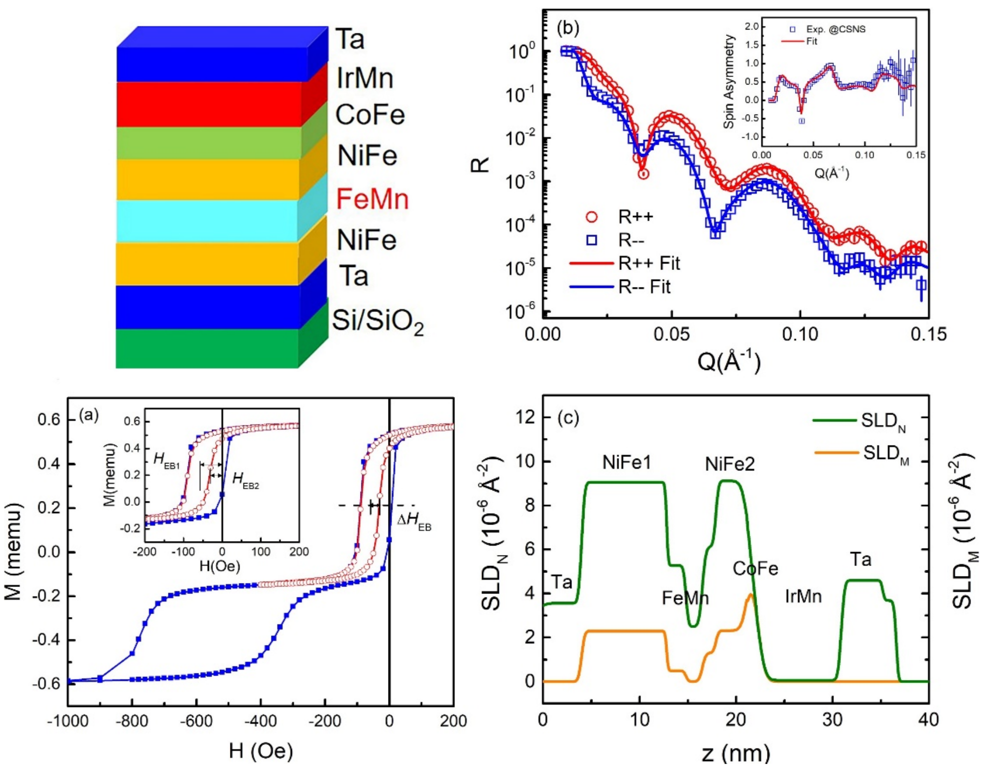
First PNR data @ CSNS

The SLD profile shows an interface between **pure Pt and MgO layers with their nominal SLDs**, which supporting an interfacial induced ISHE enhancement.

Zhu et al 2019 *J. Phys.: Condens. Matter*
https://doi.org/10.1088/1361-648X/ab172a

MR: Multipurpose Reflectometer

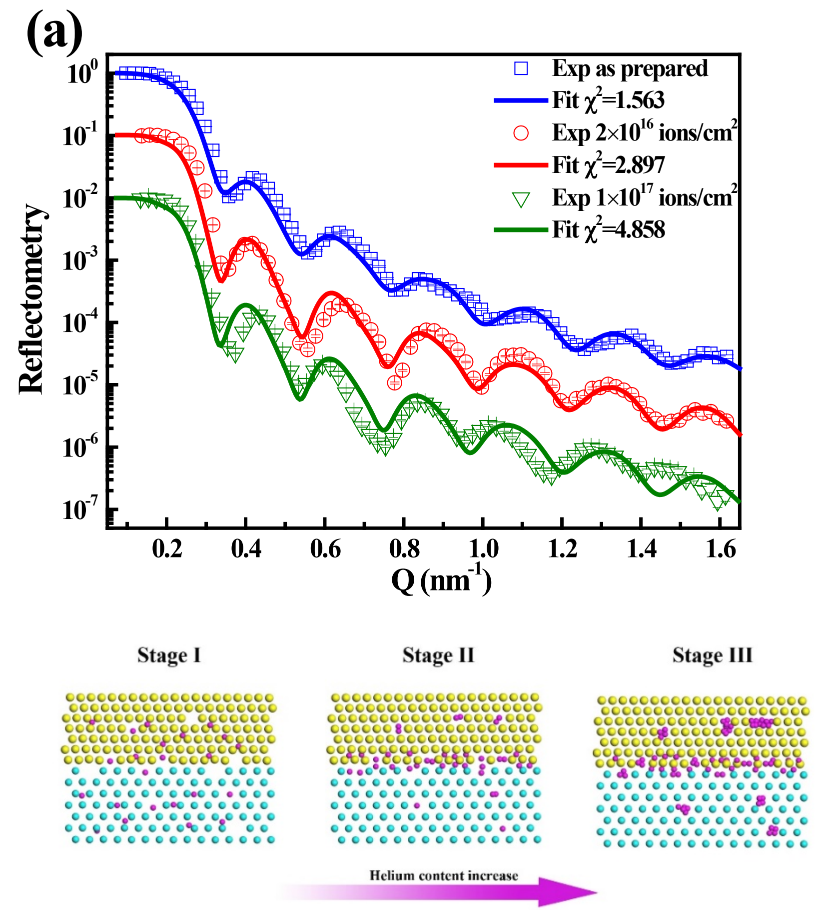
Probing the Transfer of the Exchange Bias Effect by Polarized Neutron Reflectometry



Sensitivity to reveal the complicated magnetic structure in the film.

X.Z. Zhan et al. 2019 *Sci. Rep.* 9, 6708

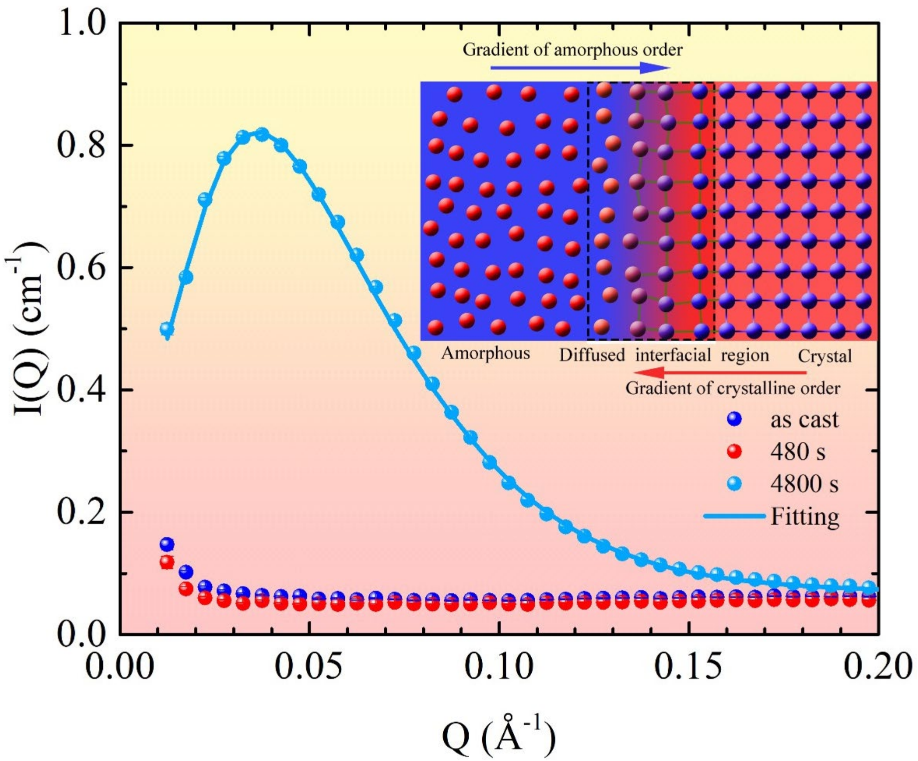
The behavior of helium atoms in He+ ion implanted W/Ni bilayer nanocomposite

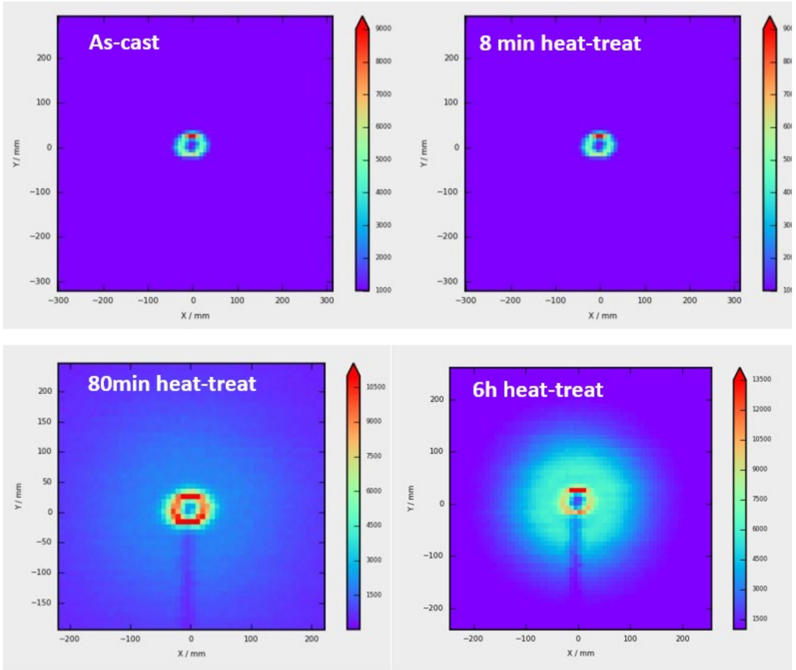


H.C. Chen et al. *Appl. Phys. Surf.* (in press)

SANS: Metal glass

The pathway of amorphous-to-crystalline phase transformation in Zr-, Fe- and Pd-based bulk metallic glasses





In-situ observation of an unusual phase transformation pathway with Guinier-Preston zone-like precipitates in Zr-based bulk metallic glasses

W.X. Dong, et al. *Acta Materials (Under Review) CityU & NUST team lead by X.L. Wang*

Running Scheme in 2019

System /Instrument	Planed Hour	Included Hour				Running Data of Similar International Advanced Facilities
		Preparation	Beam Time(for User Experiments)	Instrument Development	Downtime	
Accelerator	6000	1000	3600	1000	400	5900
Target	5600	1000	3600	800	200	3980
Instruments						
GPPD	3600	50	2800	600	150	
MR	3600	50	2600	800	150	
SANS	3600	50	2600	800	150	

Outline

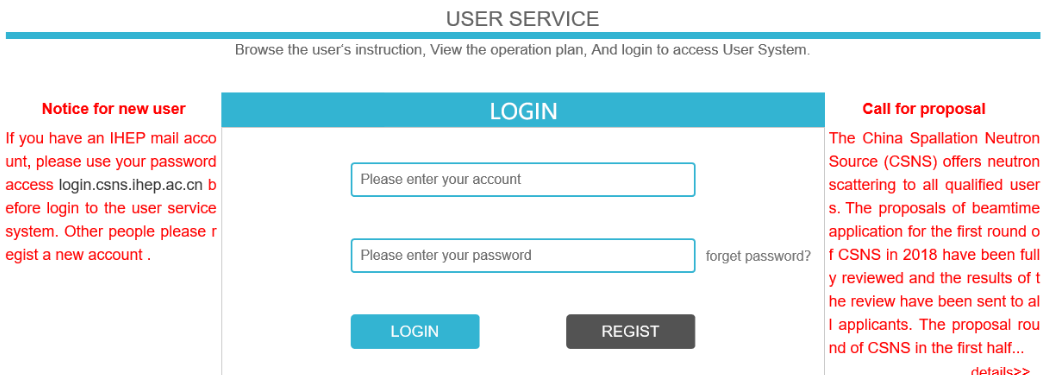
- Inst. of High Energy Physics
- CSNS project overview
- CSNS design
- Commissioning & operation
- **Users and future plan**
- Summary

User service

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

International users are welcomed

Register an account



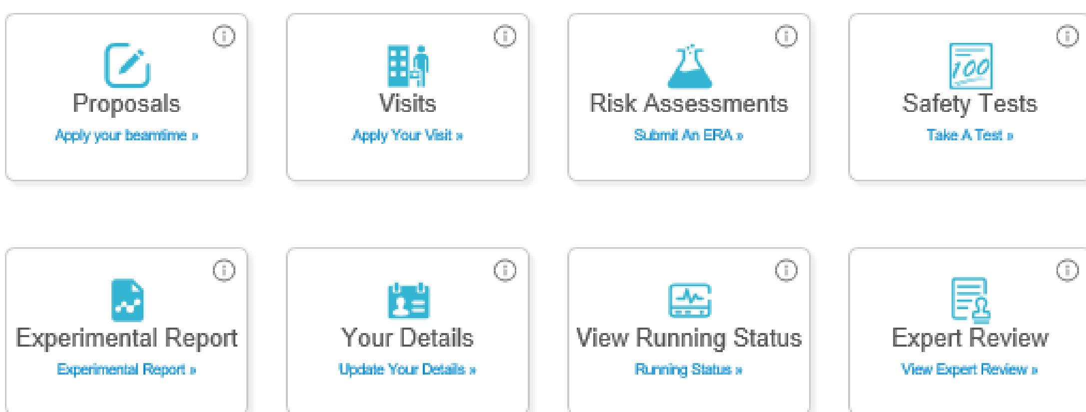
Third call for proposal:

2019.06

For third round operation

2019.09-2020. 01

Submit a proposal



Proposal type:

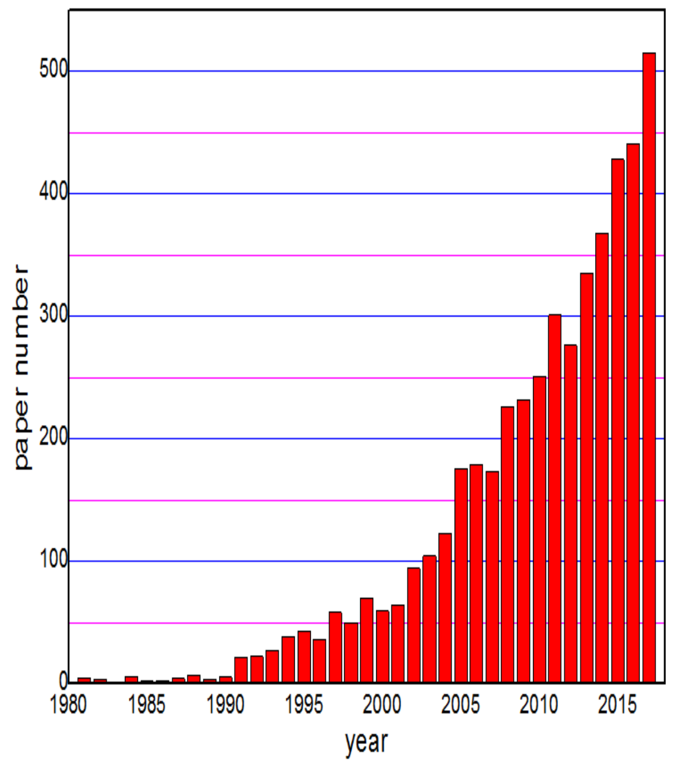
1.Direct access

2.Rapid access

User Proposals

- First operation year（Sept. 2018-June. 2019）:
  - performed 101 (included 11 from oversea and HK) (acceptance 50%)
  - Research fields: energy material, structural material， magnetic, film, alloy, polymer, nano, biology material, hydrogen storage, drug et. al.
- The current operation period（Sept. 2019 - Jan. 2020）:
  - regular application 164, 35% accepted
  - approved 57 proposals (included 7 from oversea, HK and Macao)

So far 17 user experiment result papers were published,



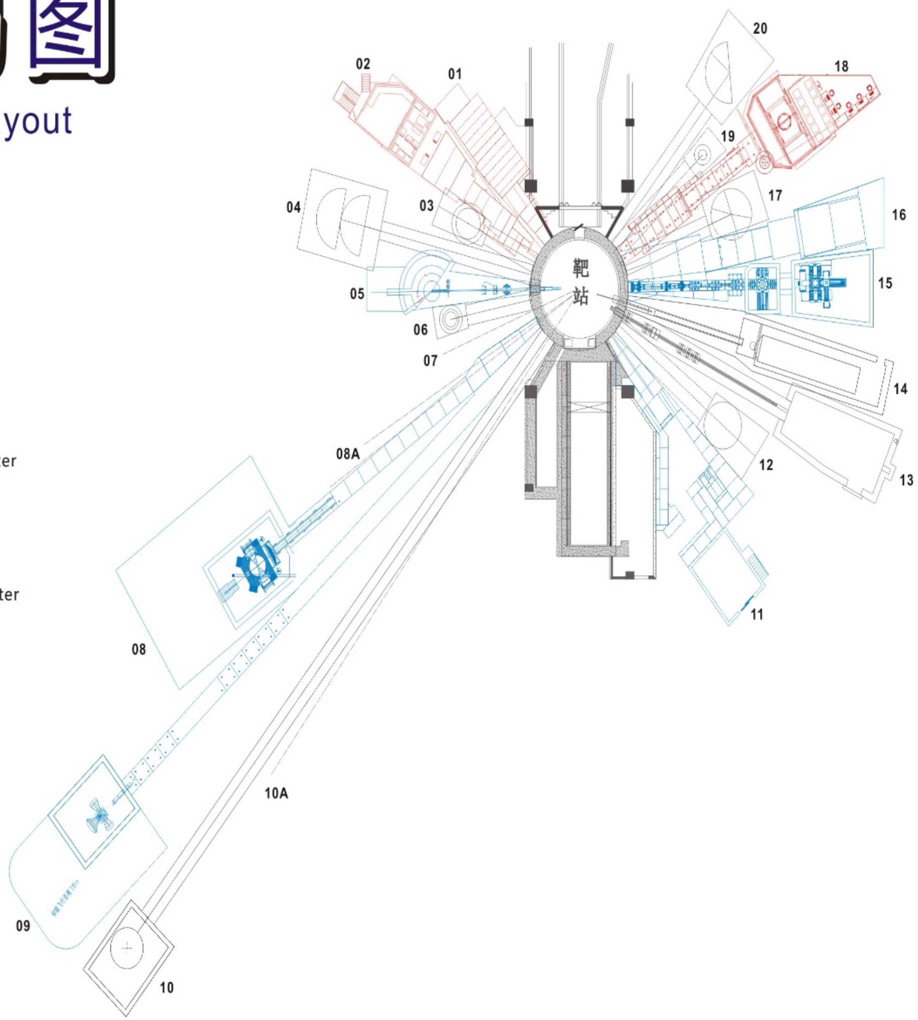
Chinese publications in neutron scattering

Instrument Layout

谱仪布局图

Neutron Instrument Layout

- **01** 小角中子散射仪
  Small-Angle Neutron Scattering Instrument
- **02** 多功能反射仪
  Multi-purpose Reflectometer
- **03** 液体中子反射仪
  Liquid neutron reflectometer
- 04 冷中子直接几何非弹谱仪
  Cold Neutron direct-geometry Inelastic Spectrometer
- **05** 高能直接几何非弹谱仪
  High Energy Direct Geometry Spectrometer
- **06** 逆几何分子振动谱仪
  Indirect geometry molecular vibrational spectrometer
- **07** 预留
  Reversed
- **08** 工程材料中子衍射仪
  Engineering Material Diffracmeter
- **8A** 中子技术测试站
  Neutron Technology Testing Station
- **09** 高分辨中子衍射仪
  High-resolution neutron powder diffractometer
- **10** 中子背散射谱仪
  Neutron BackScattering Spectrometer
- **10A** 预留
  Reversed



- **11**大气中子辐照谱仪
  Atmosphere Neutron Irradiation Spectrometer
- **12** 中子物理与应用谱仪
  Neutron Physics and Applications Spectrometer
- **13** 能量分辨成像谱仪
  Energy-resolved neutron imaging instrument
- **14** 微小角中子散射仪
  Very Small Angle Neutron Scattering Instrument
- **15** 高压中子衍射仪
  High Pressure Neutron Diffractometer
- **16** 多物理谱仪
  Multi-Physics Instrument
- **17** 弹性漫散射中子谱仪
  Elastic diffuse scattering
- **18** 通用粉末衍射仪
  General purpose powder diffractometer
- **19** 单
  Single
- **20** 直
  Direct geometry polarization inelastic spectrometer

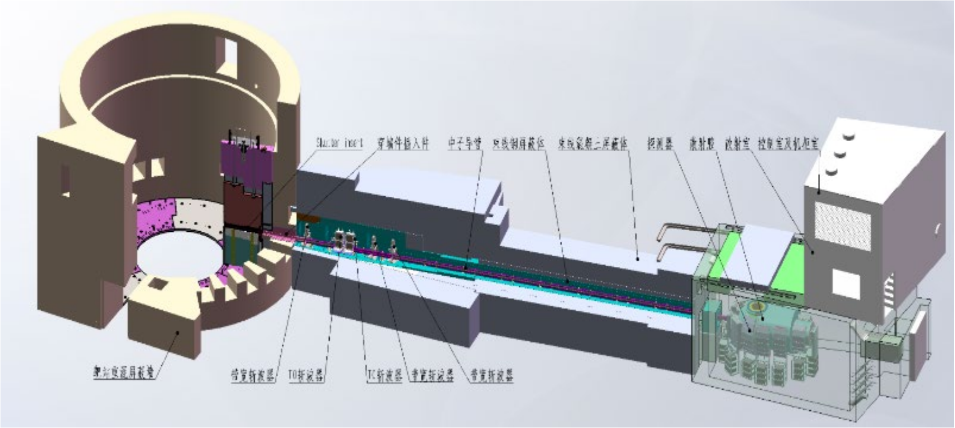
1. Multi-Physics Instrument

Total scattering diffractometer for determination of both disordered materials (PDF) and crystalline structures.

✓ 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

Moderator	Decoupled Water
First flight length	30 m
Second flight length	1~2.8 m
Q range	0.1~50 Å^{-1}
Flux on sample	10^7/n/s/cm^2
Best Q resolution	0.3%
Wavelength	0.1-3 Å
Choppers	1 double-blocks T0、3 disk choppers
Maximum sample size	30mm×30mm
Detectors	20atm, He-3tube



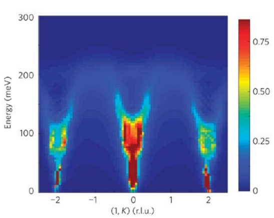
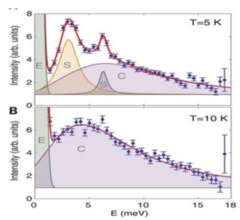
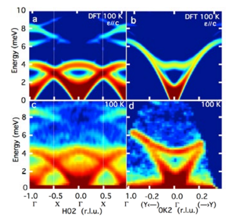
- Physical design optimization - finished
- Data analysis method of Total Scattering - developed
- Detector manufacture
  - finish ^{3}He detector purchasing and model making
- Mechanical Design – almost finished
- Neutron guide or sample environment
  - finish neutron guide purchasing,
  - the shutter insert was installed

The installation of all of the components will be finished before Dec.2020 and the commissioning of instrument will start at the beginning of the 2021.

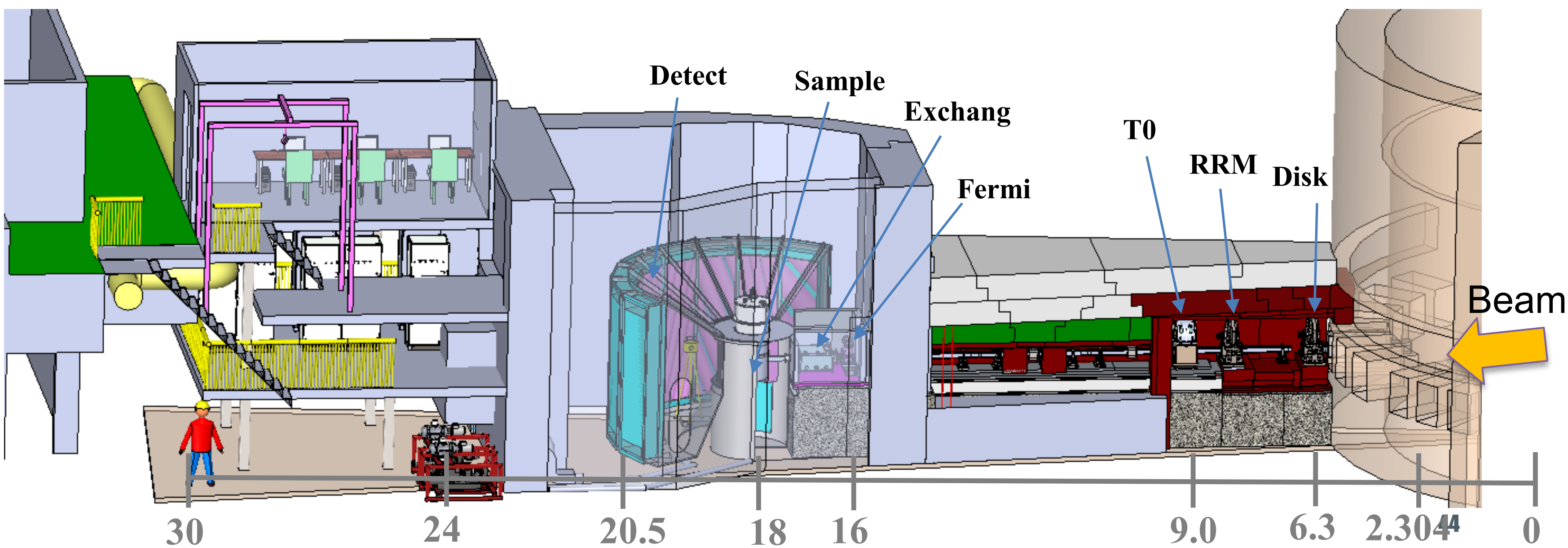
2. Direct geometry inelastic spectrometer

Scientific goal:

- High-T superconductivity
- Quantum materials
- New energy materials

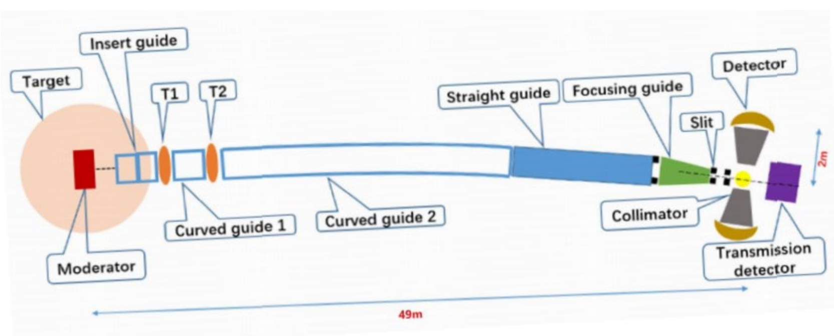
Moderator	Decoupled Water
Resolution	10meV~1500meV: 3%~10%
Flux	10~1500meV: $1*10^7 n/s/cm^2$@100kW
Beam size（sample）	MAX: 3cm×3cm
Detector coverage	horizontal: -30˚～+130˚ vertical: -30˚～+30˚
Sample size	3cm×3cm
sample—moderator	18m
fermi—sample	2m
sample—detect	2.5m
Sample environment	High and low temperature（3K~600K） Superconducting magnet（～7T）

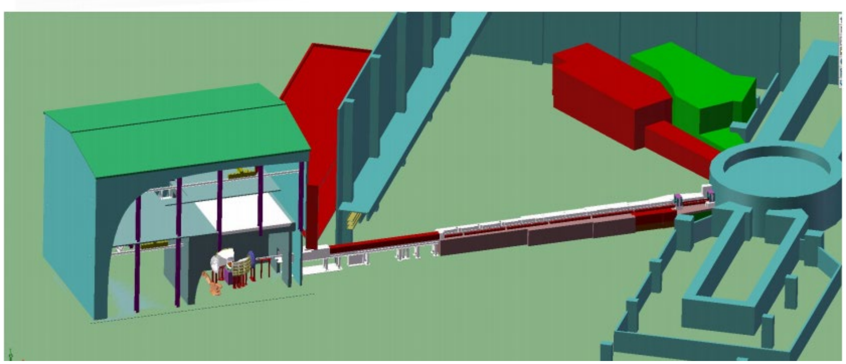


3.Engineering Material Diffractometor

Features

- High spatial resolution
- Near surface residual stress measurement
- 3D residual stress measurement
- 3D texture measurement
- For big engineering component
- In-situ process measurement (e.g. 3D printing）





Moderator	Decouple Poisoned Liquid hydrogen
Flight path	L1=49.5m, L2=2m
Range of wavelength	0.5~6 Å; Δλ=3.1Å @25Hz
Resolution (Δd/d)	0.25%@90°
Neutron intensity	≧10^6 n/s/cm^2
Radial collimator	1,2,3,4mm
Detectors	horizontal coverage angle: 90°±15°, vertical coverage angle: ±20°, pixel: 3~4 mm (H)*150~200 mm (V)
Sample Table	size: 1800mm*1800 mm load capacity: 2T
Temperature range of In-situ measurement	-270℃~1400℃

Time schedule

2019: Physical design finished

2020: Infrastructure construction finished

I2021: Neutron guide installation finished

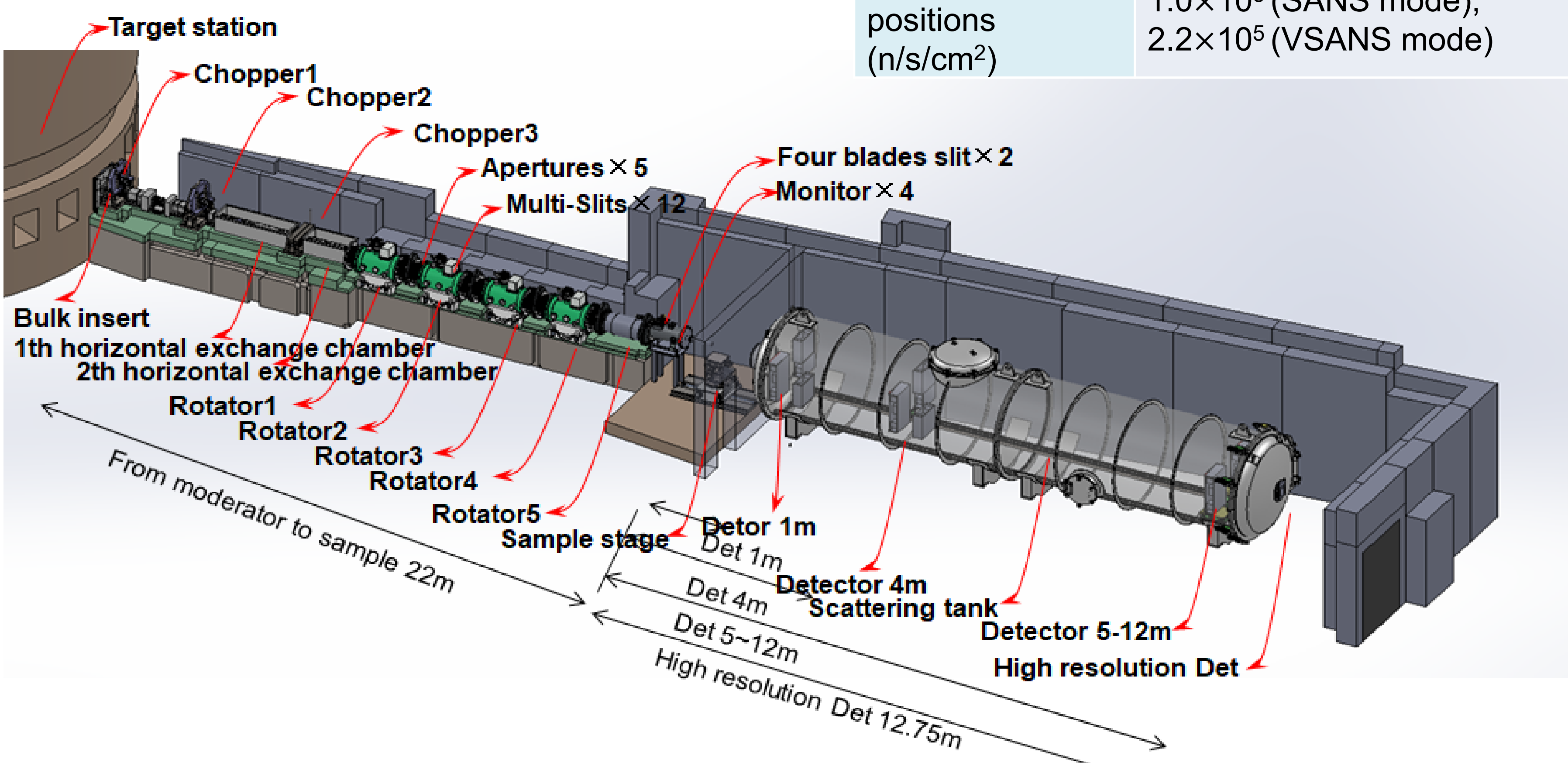
2022: Commisioning and acceptance before 31, July.

4. Very small angle neutron scattering

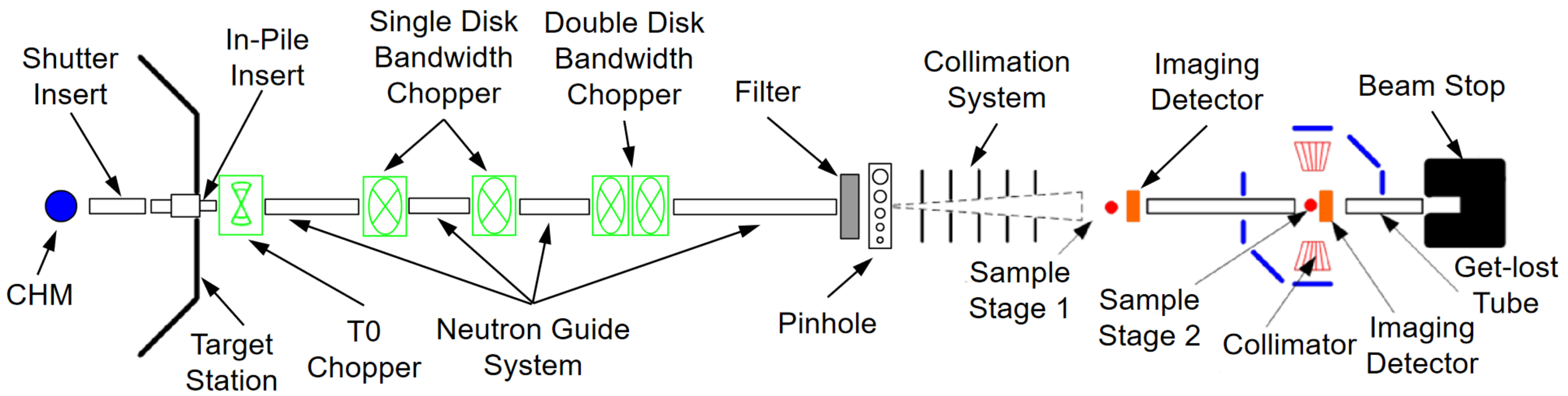
Scientific goal :

Structure-Property relationship on multiphase and multiscale in the field of nano, biology, polymer, giant and super molecular science.

Moderator	Coupled liquid hydrogen
Wavelength (Å)	2.2-6.7 (25 Hz), 2.2-11.2 (12.5 Hz)
Q range ($Å^{-1}$)	0.0004-0.02 (VSANS mode), 0.003 -1.5 (SANS mode)
Source-Sample distance (m)	2.5 (SANS mode), 12.75 (VSANS mode)
Flux at sample positions ($n/s/cm^2$)	1.0×10^8 (SANS mode), 2.2×10^5 (VSANS mode)

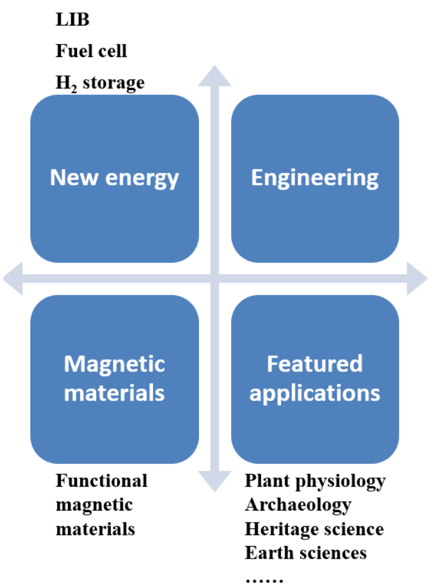


5. Energy-resolved Neutron Imaging



Design specifications

- Bragg edge imaging, conventional neutron imaging, neutron diffraction
- Spatial resolution: ~ 50 μm
- Wavelength resolution: < 0.5%
- Maximum FOV: 200 x 200 mm^2
- Maximum neutron flux: ~ 10^7 $n/cm^2/s$
- Platform for advanced imaging methods: grating imaging, polarized imaging, ultra high resolution, et al



6. High Pressure Neutron Diffractometer

A **"general purpose"** <u>High Pressure</u> Powder Diffractometer and Imaging Instrument

Wide application:

mineral, ceramics, hydrate, organics;

structure, magnetism, deformation;

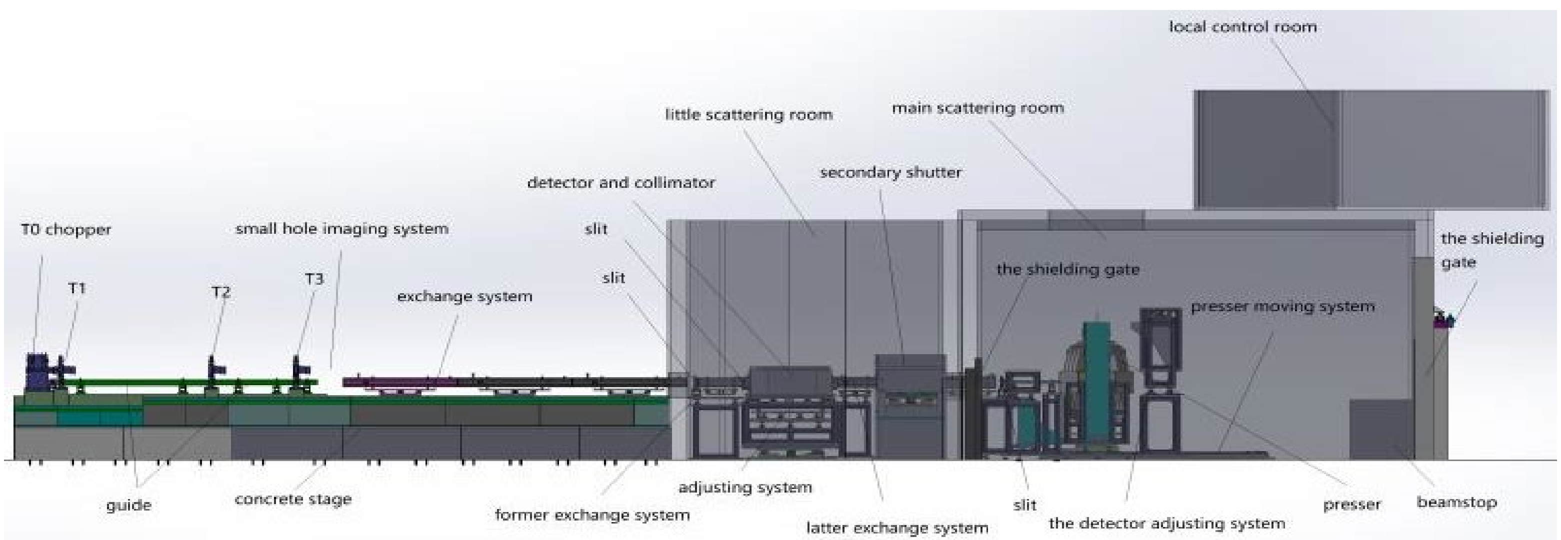
Earth&Geology, Material, Energy, Environment

Multiple sample environment:

High Pressure: 3-axis large press, opposed anvil, piston cylinder, gas/liquid press cell etc.

High temp.; Low temp; magnetic field

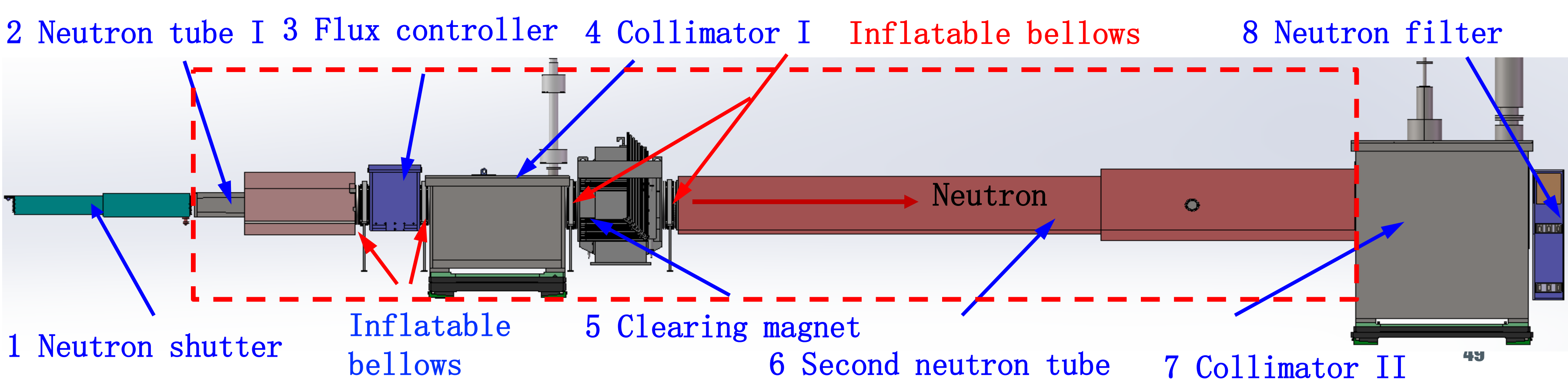
Moderator	Decoupled Water
L1	S1-22.5m/S2-29m
L2	Diffraction：S1-1m/S2-1.5m Imaging：~2m
Max beam size at sample position	Diffraction：20mm×20mm Imaging：≥40mm×40mm
Best Resolution at 90 degree	S1~0.7%/S2~0.6%
Flux at sample position	Diffraction：≥5×106 n/cm2/s
d range for 90 degree	S1:0.5-4.1Å S2:0.5- 3.6Å
Resolution for imaging	50-100 microns



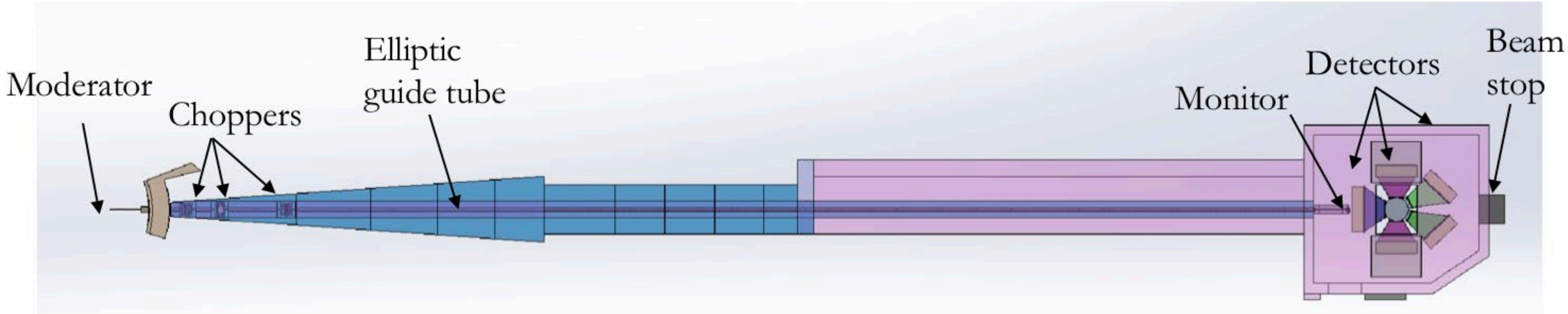
7. Atmospheric Neutron Irradiation Spectrometer

- Neutron single event effect test for semiconductors, electronic devices and integrated equipment used in aviation and ground
- Nuclear physics, nuclear data, neutron technology experiments

Target view	ANIS Views the front part of target
Charged particles	Deflected by a 0.5T clearing magnet
spectrum	matches JEDEC standard spectrum.
Collimated beam	From 10cm×10cm to 1cm×1cm
Scattered beam	From 65cm×65cm to 80cm×80cm, and 40cm×40cm beam
Intensity	104~107 n/cm2/s for collimated beam 103~107 n/cm2/s for scattered beam
Uniformity	beam uniformity <10%
Sample area	Irradiation room with 6m(long) ×3m(width) ×2.8m(high) First sample position at 20 m, second at 25 m



8. High-resolution Powder Diffractometer



Best resolution of Δd/d < 0.05%

Applications

- Detecting tiny structural changes that significantly influence properties like superconductivity, colossal magnetoresistivity, multiferroicity *etc.* in condensed matters physics.
- Solving complex crystal or magnetic structures in advanced functional materials such multiferroics, energy storage materials, catalysts, small-molecular medicine *etc.*
- Studying phase transitions.

Moderator	Decoupled poisoned hydrogen
Flight path	L1=80.0 m， L2=2.0 - 4.0m
Best resolution	<0.05%
Flux	~ 1×10^6 n/s•cm^2
d-range（high angle bank）	0.1-4Å@6.25 Hz
d-range（low angle bank）	0.2-25Å@6.25 Hz

Future Plan

CSNS Phase II （14th 5 year plan from 2021 ）:

- More neutron Instruments （10 instruments)
- More sample environment and user lab.
- Beam power upgrade to 500kW：
  - LINAC beam energy upgrading to 300MeV by SC cavities. The tunnel is available.
  - RCS works for 500kW with minor upgrade
  - Target upgrading to 500kW: new target and modulators. (shielding and utility fulfill 500kW)

Long term

- Second target stations
- Muon beams
- ……

South Advance Light Source proposed 3GeV, 4th gerenation

Summary

- CSNS finished construction and reached the specifications on schedule, and passed the national acceptance on Aug. 2018. It opened to users.
- The CSNS operation runs stable with high efficiency, and the performance is improving.
- The user demand is very strong. 17 papers of the user experiment results published.
- The design and construction of user instruments are underway.
- The phase-II instrument construction and the power upgrade are expected to be started 2021.
- CSNS look forward for more exchange and cooperation with ESS in the high power proton accelerator, target, instruments as well as the neutron scattering and applications.

Thank you！

Neutron instruments layout