The Introduction to CSNS and Its Upgrade Project CSNS-II

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Institute of High Energy Physics, CAS, May. 26, 2025

Outline

I. The status of CSNS

II. The nuclear physics experiments at CSNS

III. The Upgrade project CSNS-II

IV. The R&D and construction progress of CSNS-II

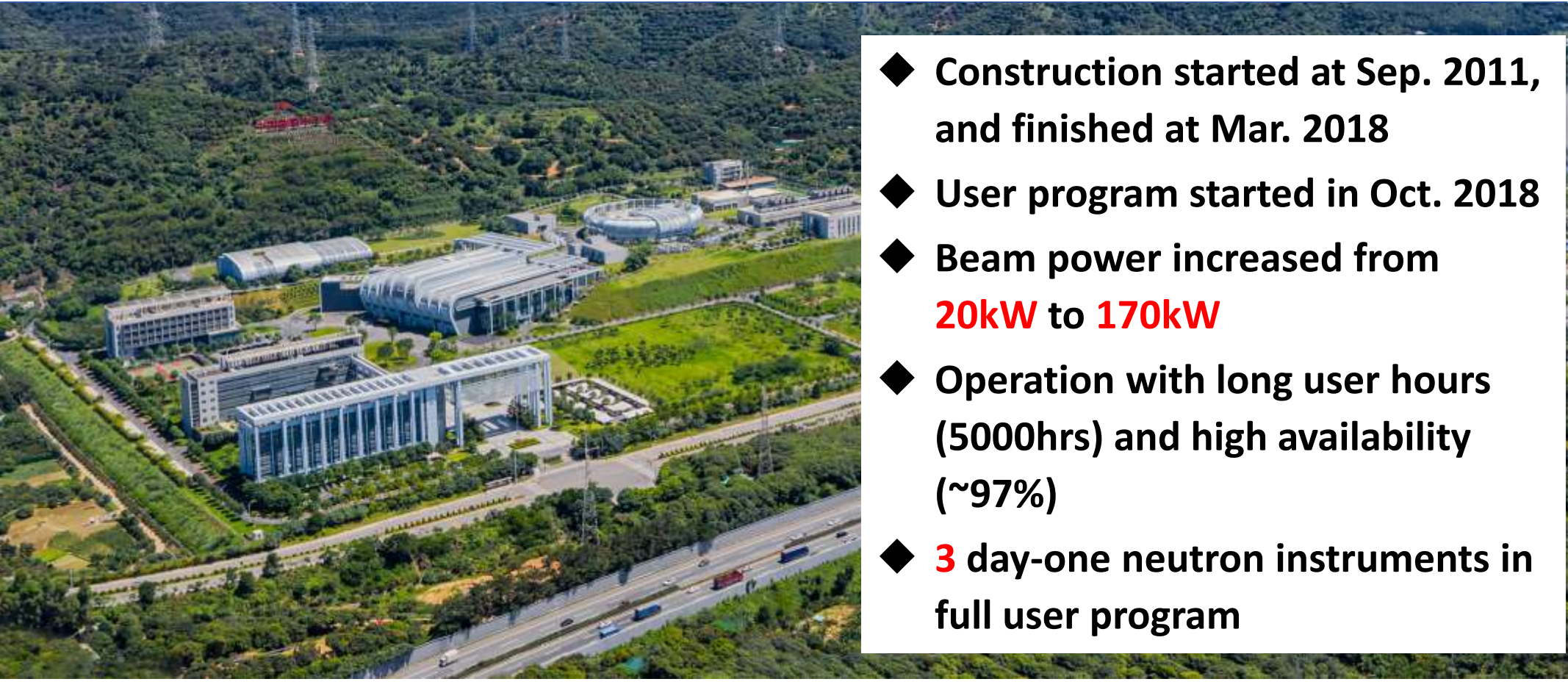
V. Summary

The Status of CSNS

The Location of CSNS

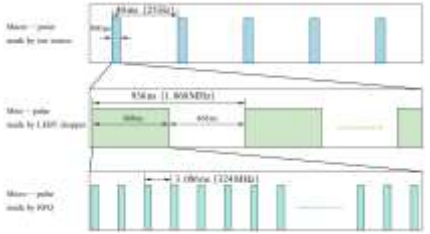
The large scientific facilities of IHEP

The Campus of Dongguan Branch

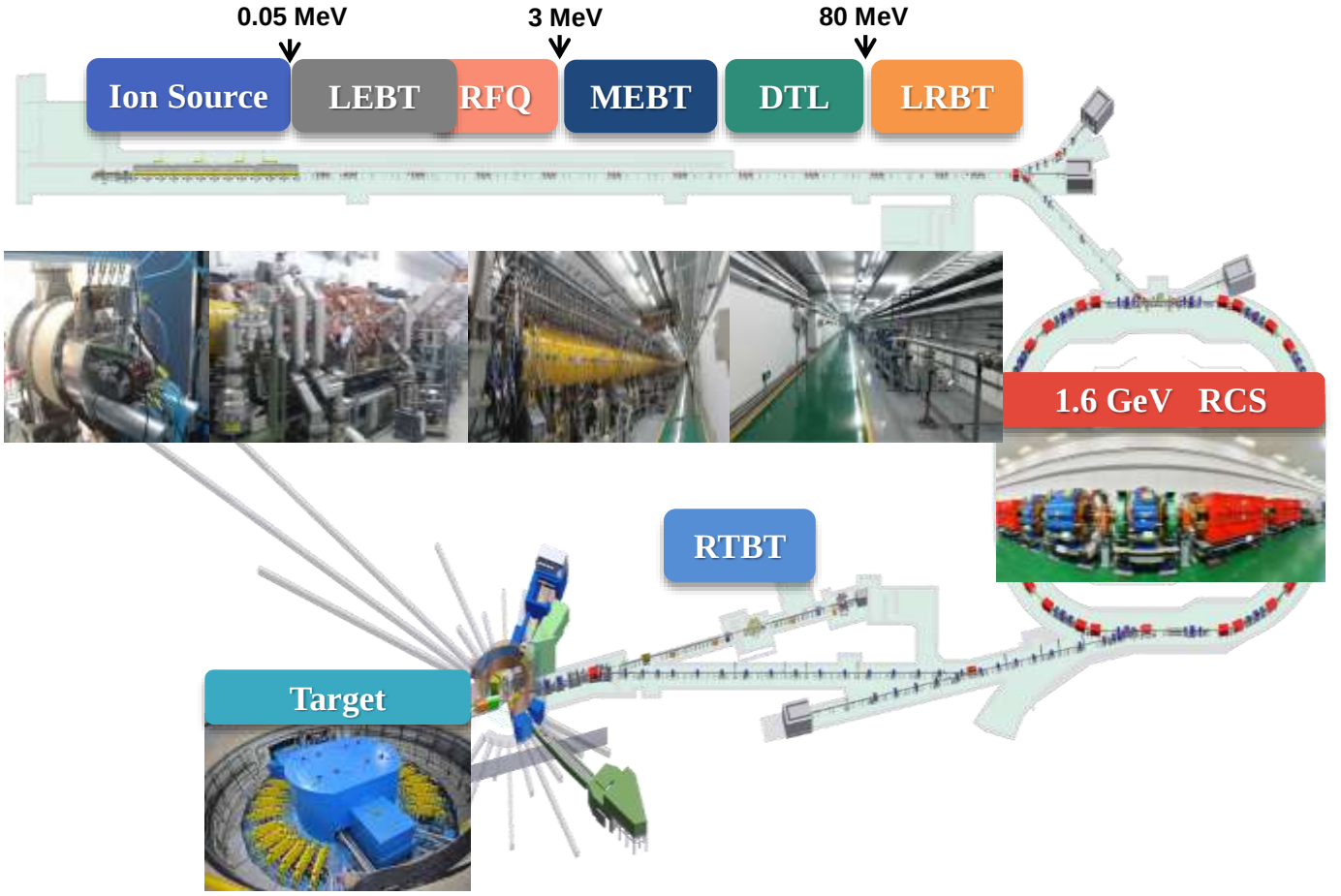


- Construction started at Sep. 2011, and finished at Mar. 2018
- User program started in Oct. 2018
- Beam power increased from 20kW to 170kW
- Operation with long user hours (5000hrs) and high availability (~97%)
- 3 day-one neutron instruments in full user program

CSNS Facility

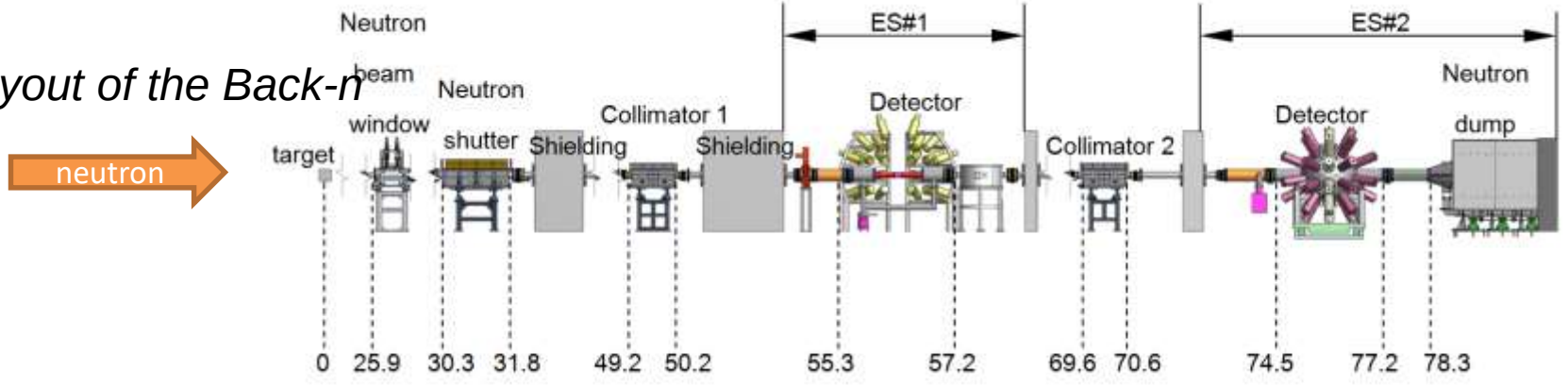


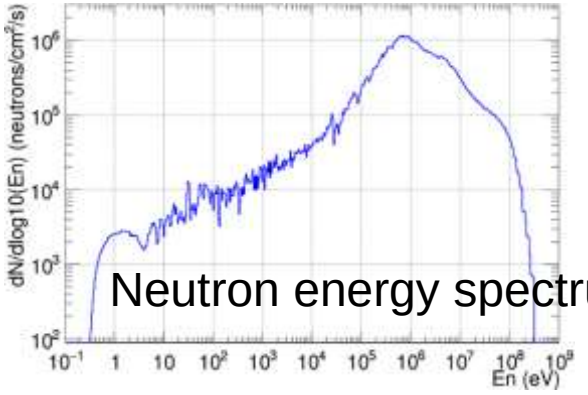
Beam Power on target [kW]	100
Proton energy [GeV]	1.6
Average beam current [uA]	62.5
Pulse repetition rate [Hz]	25
Linac energy [MeV]	80
Linac type	NC
Linac RF frequency [MHz]	324
Macropulse duty factor	1.05
RCS circumference [m]	228
RCS harmonic number	2



Back-n White neutron source

Layout of the Back-n





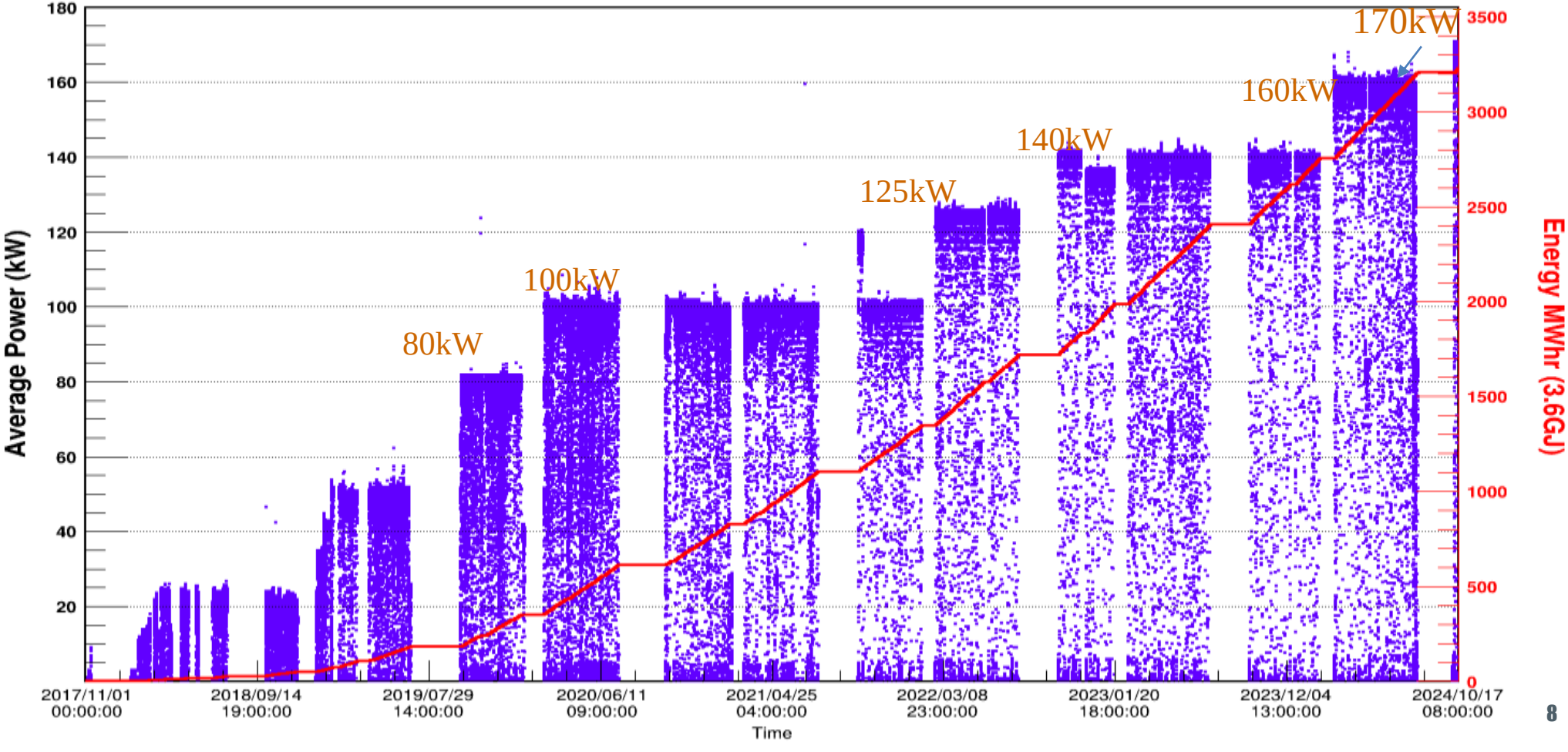
Neutron energy spectrum

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}

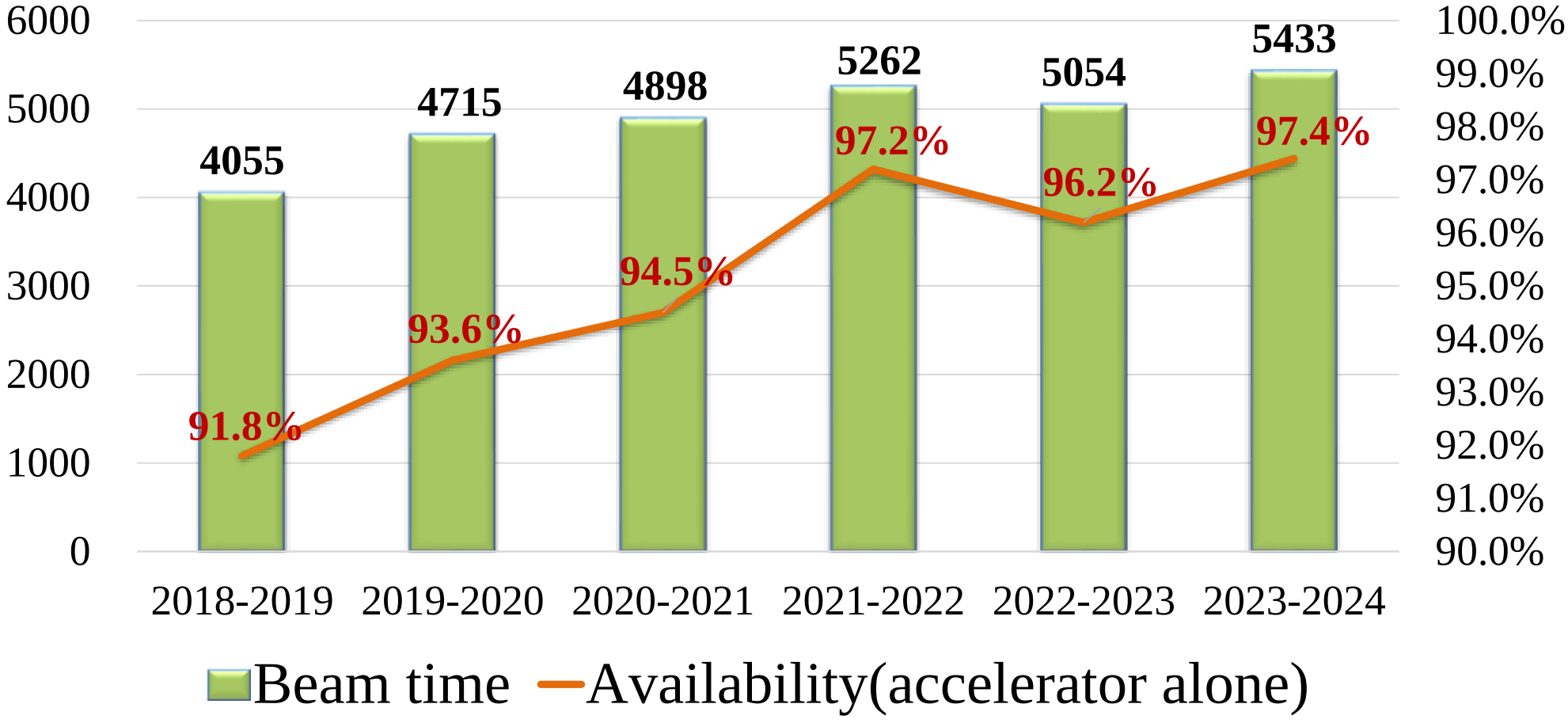
- The back-streaming neutrons are leading to the Back-n tunnel
- The ES#1: 55m
- ES#2: 70m
- Thermal neutrons to 300 MeV.
- The highest neutron flux: 1E7 n/cm^2/s.
- different neutron beam spots and fluxes can be obtained yy using different collimator

It is the world's highest neutron flux white neutron beamline.

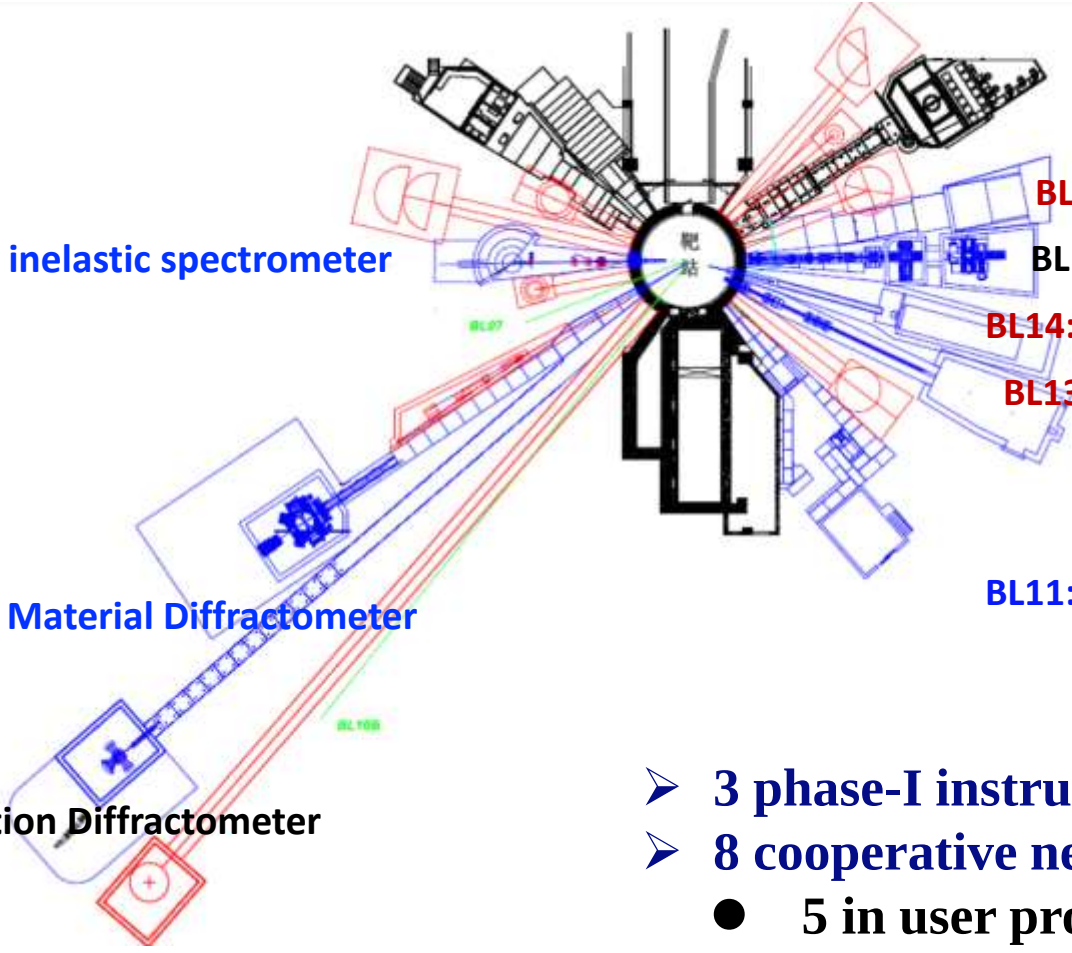
CSNS Beam Power History



User hours and Availability



Neutron Instruments



BL16: Multiple Physics Instrument

BL05: High energy inelastic spectrometer

BL15: High Pressure Diffractometer

BL14: Very small angle neutron scattering

BL13: Energy resolved neutron imaging

BL11: Atmosphere Neutron Irradiation

BL08: Engineering Material Diffractometer

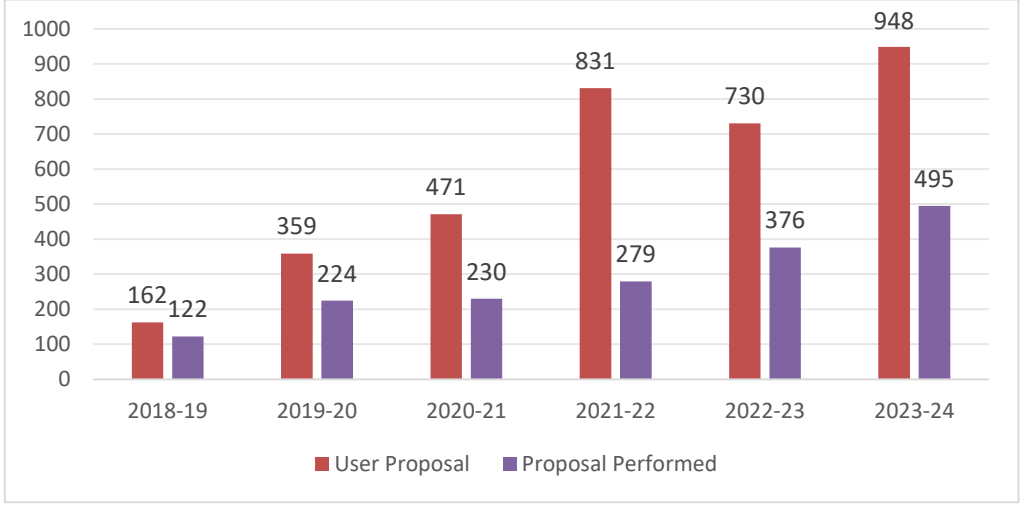
BL09: High resolution Diffractometer

- 3 phase-I instruments
- 8 cooperative neutron instruments
  - 5 in user program
  - 3 in trail user operation

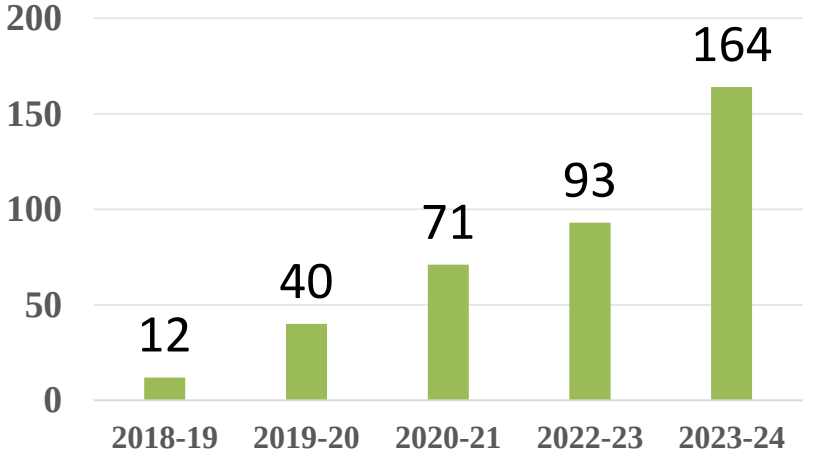
User Program

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

- Registration user: 8000+ (130+ abroad)
- A total of over 2,000 projects from ~240 units were completed, with industry users comprising approximately 10% of the total.
- Two rounds of proposal calls each year

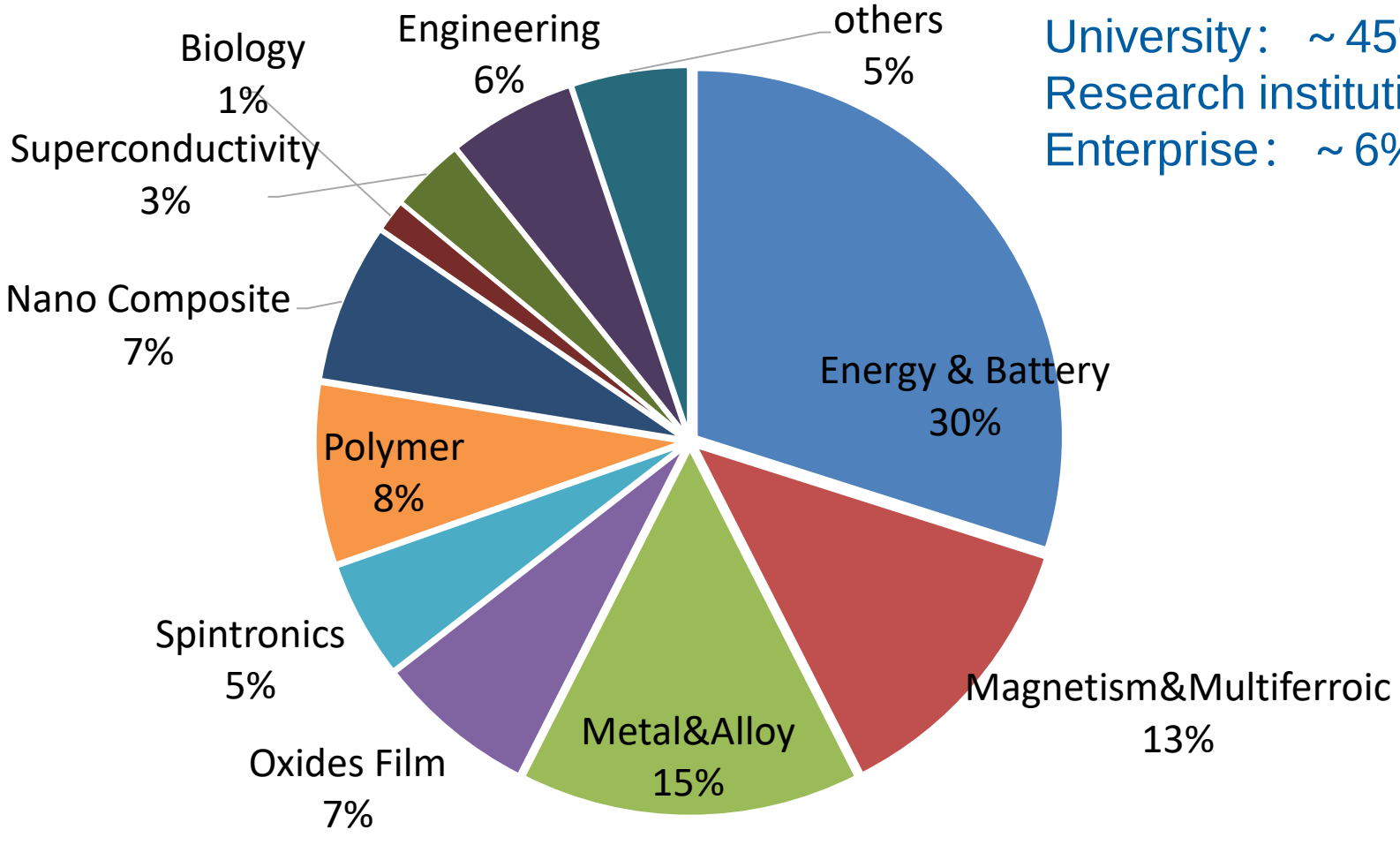


User proposal VS. Proposal proved



User publication

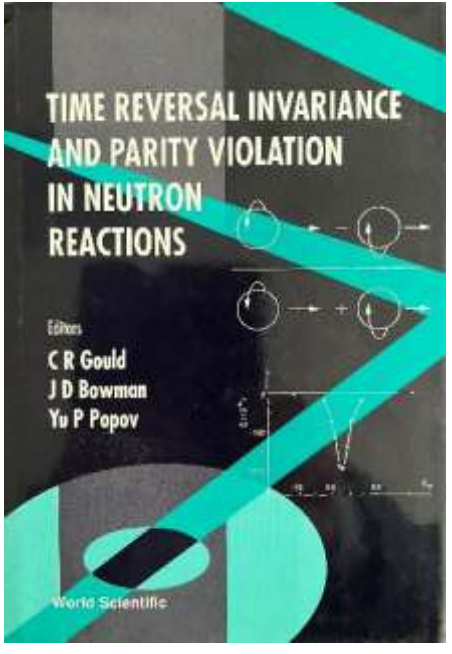
Research Areas



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

Parity and Time reversal violation in CSNS

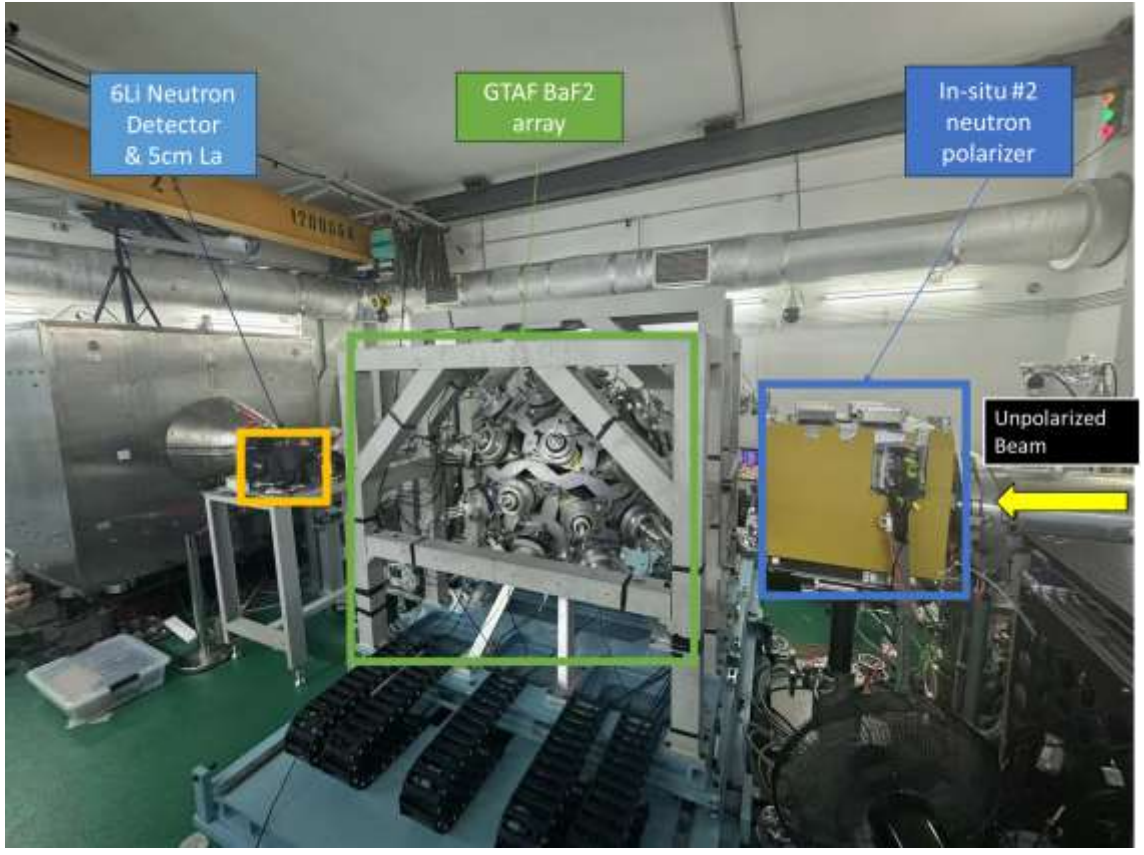
The cover of the conference proceedings of the first ISINN conference



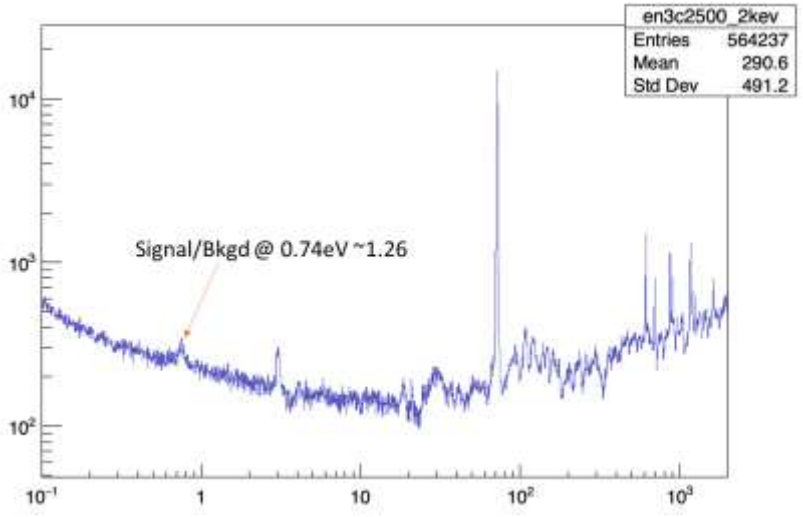
CSNS is currently a member of the NOPTREX international collaboration, which is dedicated to experiments on parity and time reversal violation in neutron-nuclear reactions.

See **Hirohiko Shimizu**'s report at **11:30 AM today in Plenary Session**.

Parity Violation experiment at Back-n



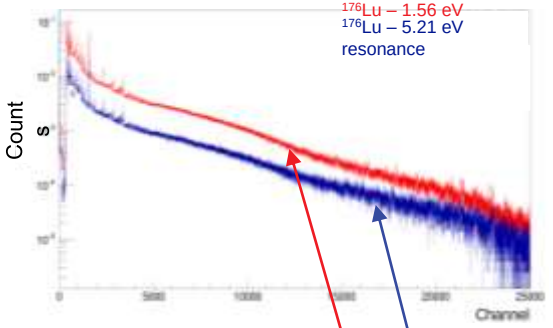
Experimental photos

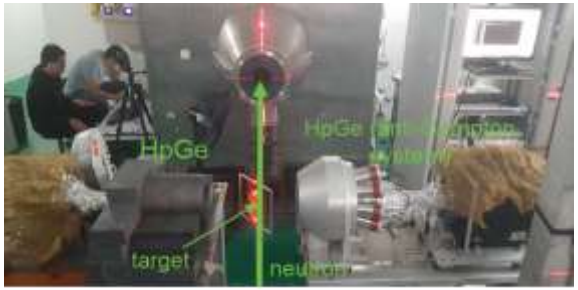


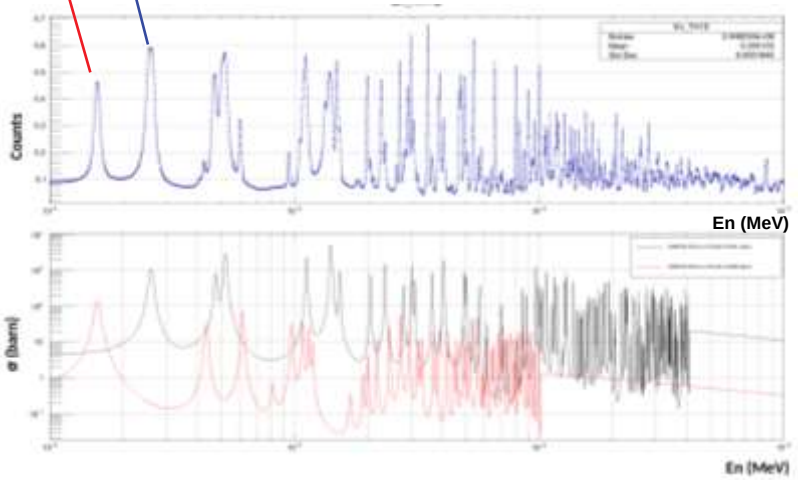
In January 2025, a groundbreaking collaboration between Indiana University, the China Institute of Atomic Energy (CIAE), Shandong University (SDU), Great Bay University (GBU), and the China Spallation Neutron Source (CSNS) successfully conducted the first experimental attempt on parity violation at the Back-n facility.

The nuclear physics experiments of FLNP at CSNS

The team of Professor Yury Gledenov in the CSNS







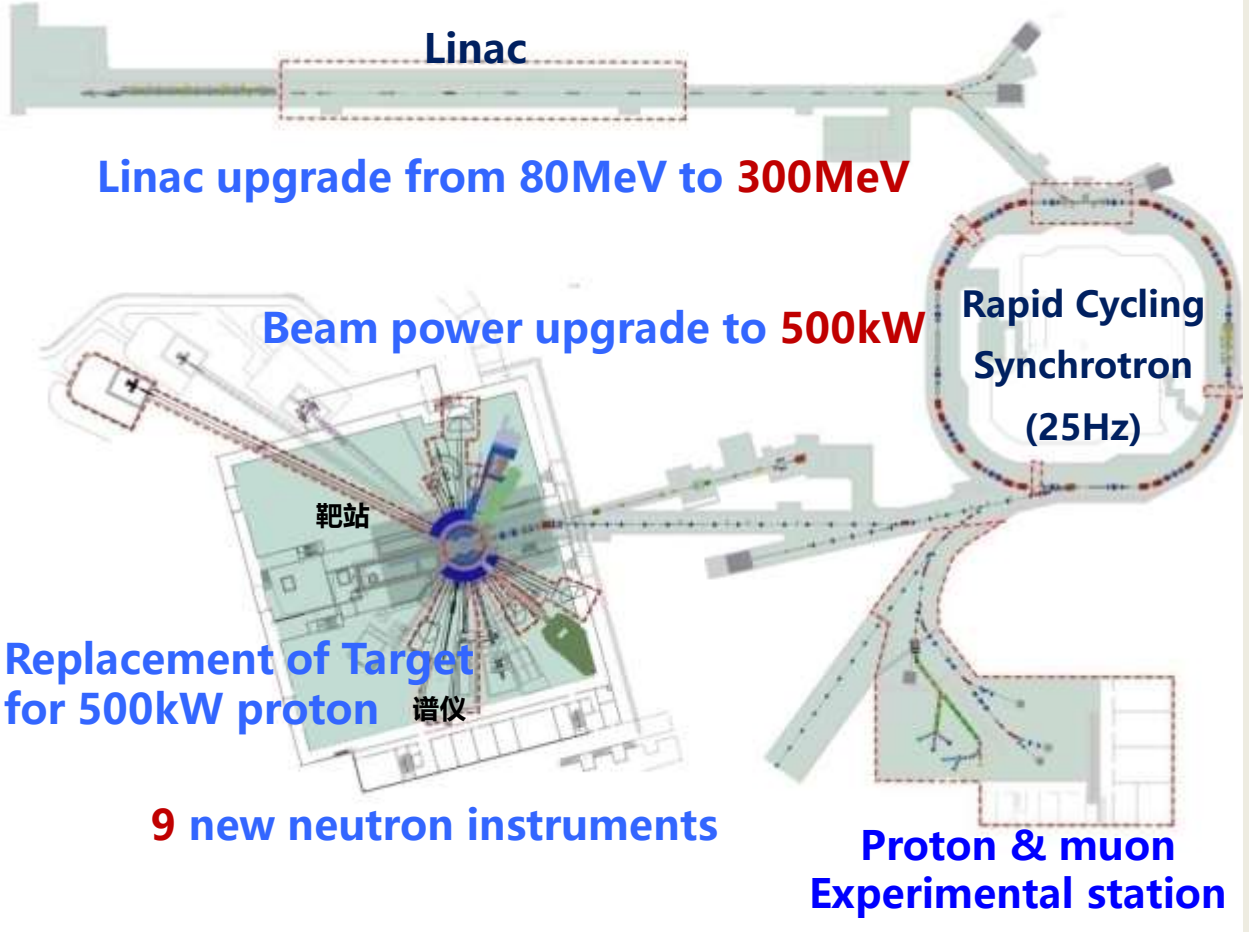
Nuclear physics experiments have been conducted or will be conducted:

- ^{176}Lu and ^{177}Lu Resonance Neutron Capture
- Forward-Backward Asymmetry Coefficient in the ^{35}Cl(n,p)^{35}S

See **Gadir Ahmadov (JINR)** 's report at **11:40 AM on Tuesday in Parallel session 1**

The Upgrade project: CSNS-II

China Spallation Neutron Source-II

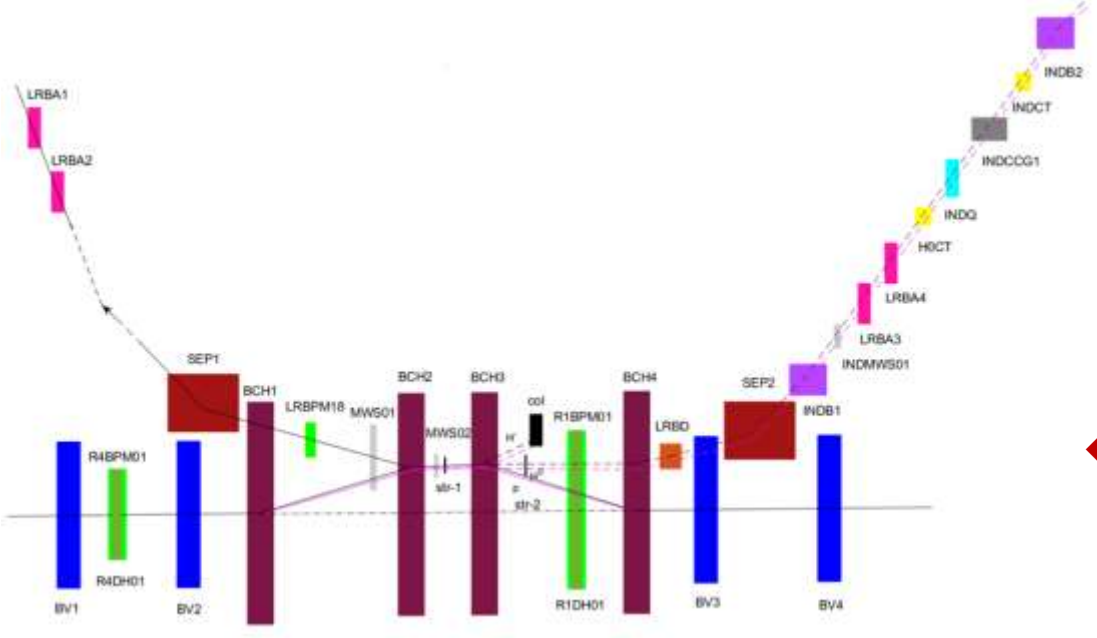


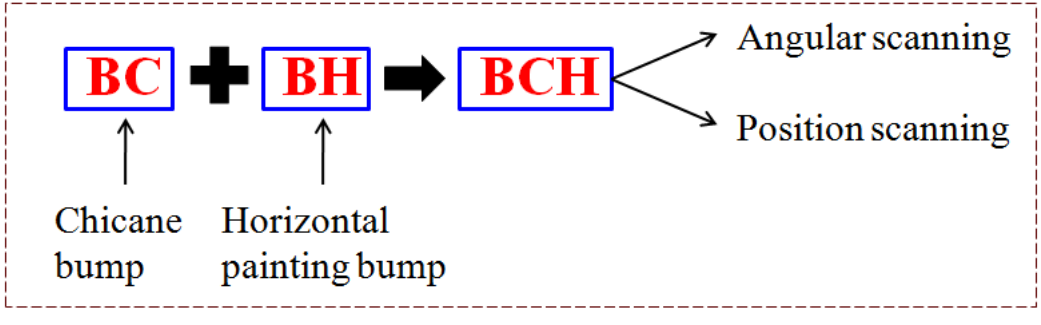
- Project Budget: 2.9 B CNY
- Funded by central and Guangdong local government
- Design and R&D completed
- Construction: 2024.1~2029.10 (5 years and 9 months)

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

A new injection scheme





- New idea: chicane bump and horizontal painting bump are combined into one bump which make the chicane bump "move". The horizontal painting is performed by using the position and angle scanning at the same time.

◆ **Advantages:**

◆Peak temperature of the stripping foil can be greatly reduced.

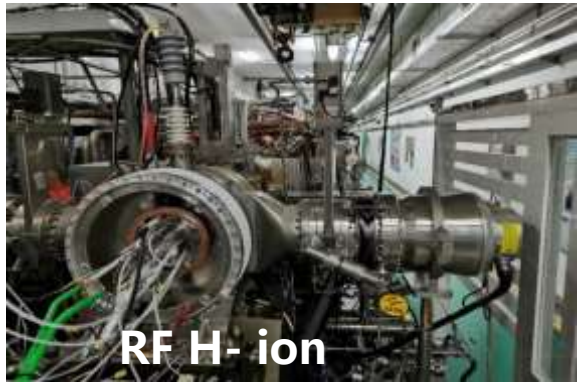
◆Both correlated and anti-correlated painting can be performed.

◆The edge focusing effect of bump magnets is greatly reduced

◆The difficulty of large aperture of the injection port and transport line required by angular scanning is solved.

◆It saves a set of bump magnets and is easier to optimize the layout of the injection system.

R&D for the Linac


RF H- ion


Spoke cavity and cryomodule prototypes


7-cell pi-mode debuncher


648MHz klystron power

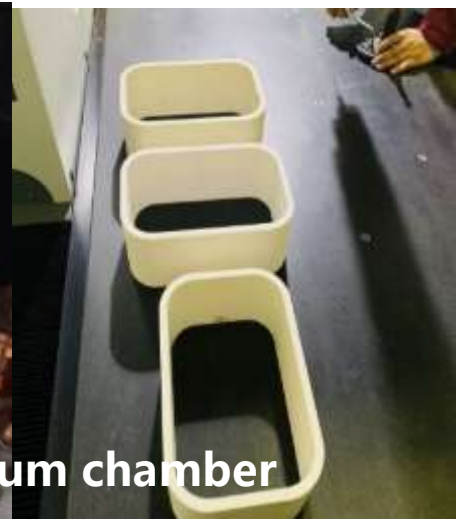

Long-pulse solid-state modulator

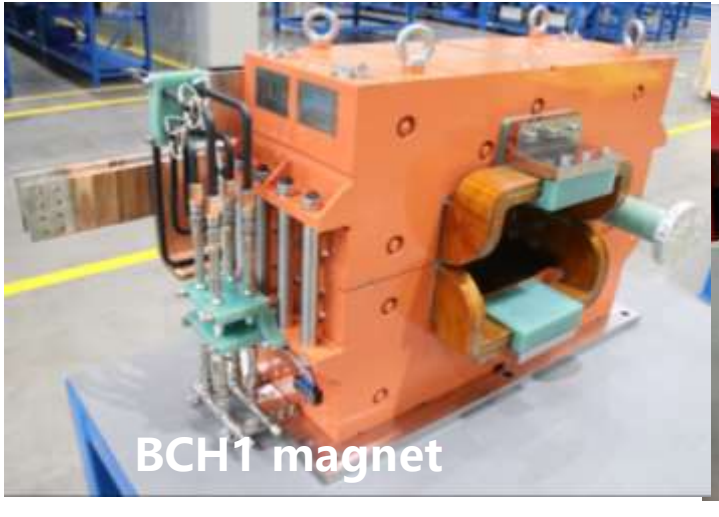

Low-level RF

R&D for the RCS

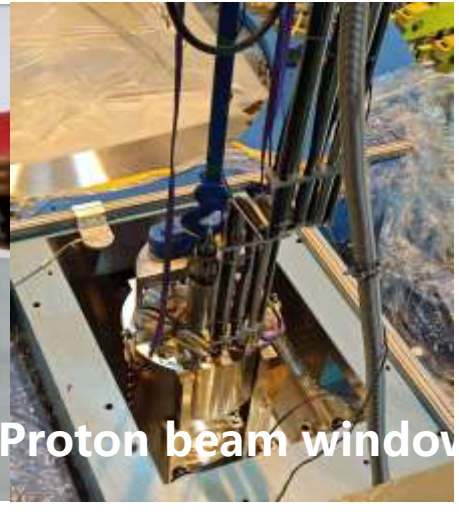

MA second harmonic cavity


Ceramic vacuum chamber

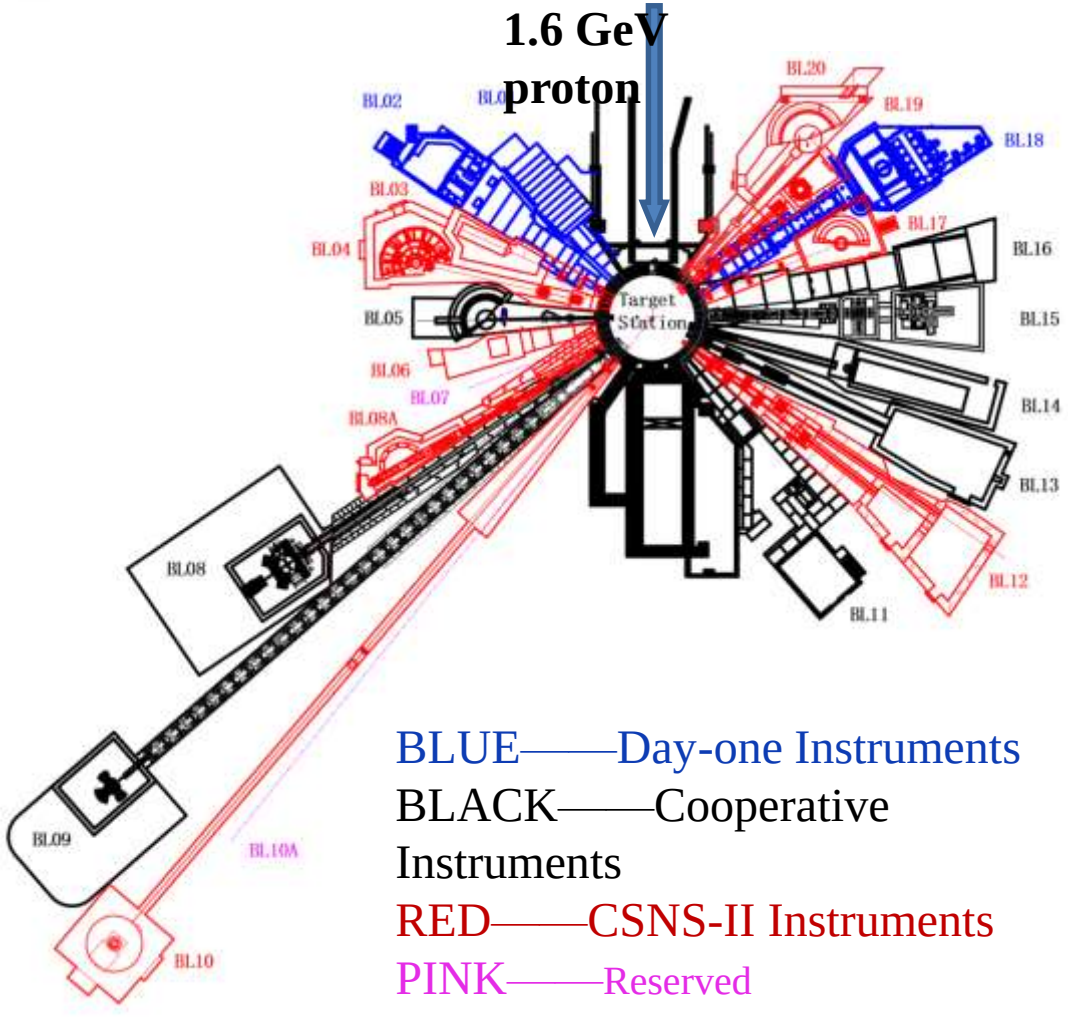



BCH1 magnet


momentum collimator


Proton beam windov

Neutron Instruments for CSNS-II



BLUE——Day-one Instruments

BLACK——Cooperative Instruments

RED——CSNS-II Instruments

PINK——Reserved

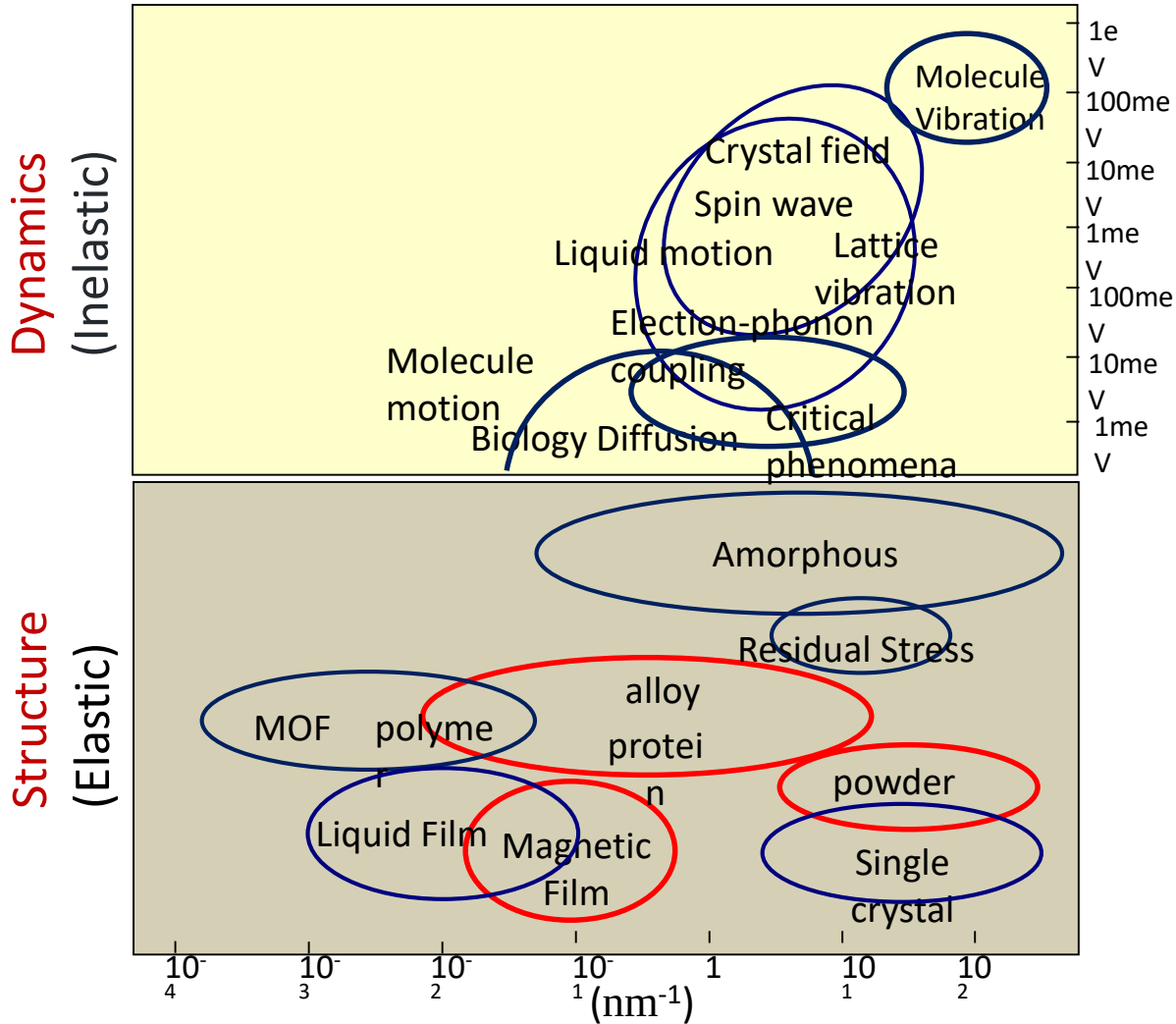
Location	Instrument
BL01	Small Angle Neutron Scattering
BL02	Multiple Purpose Reflectometer
BL03	Liquids Neutron Reflectometer
BL04	Cold Neutron Inelastic Spectrometer
BL05	High Energy Direct Geometery Inelastic Spectrometer
BL06	Molecular Vibrational Spectrometer
BL07	Reserved
BL08	Engineering Material Diffracmeter
BL08A	Neutron Technology Testing Station
BL09	High-resolution Neutron Powder Diffractometer
BL10	Neutron Backscattering Spectrometer
BL10A	Reserved
BL11	Atmosphere Neutron lrradiation Spectrometer
BL12	Neutron Physics and Application Instrument
BL13	Energy-resolved Neutron lmaging Instrument
BL14	Very Small Angle Neutron Scattering Instrument
BL15	High Pressure Neutron Diffractometer
BL16	Multi-Physics Instrument
BL17	Elastic Diffuse Scatting Spectrometer
BL18	General Purpose Powder Diffractometer
BL19	Single Crystal Neutron Diffractometer
BL20	PolArized Chopper Spectrometer

Application Area of CSNS-II

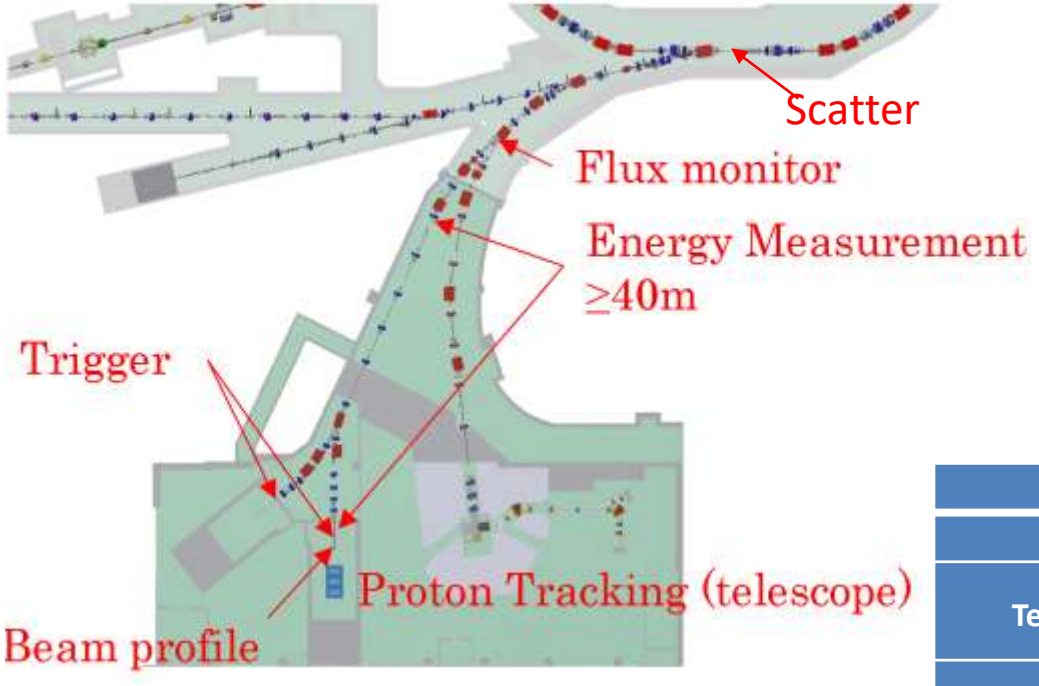
- The existing instruments cover some structural applications
- The Phase II spectrometers will cover the majority of user demands in various fields, enabling characterization of structures and dynamic measurements.

CSNS Inst.

Cooperation&CSNS-II inst.



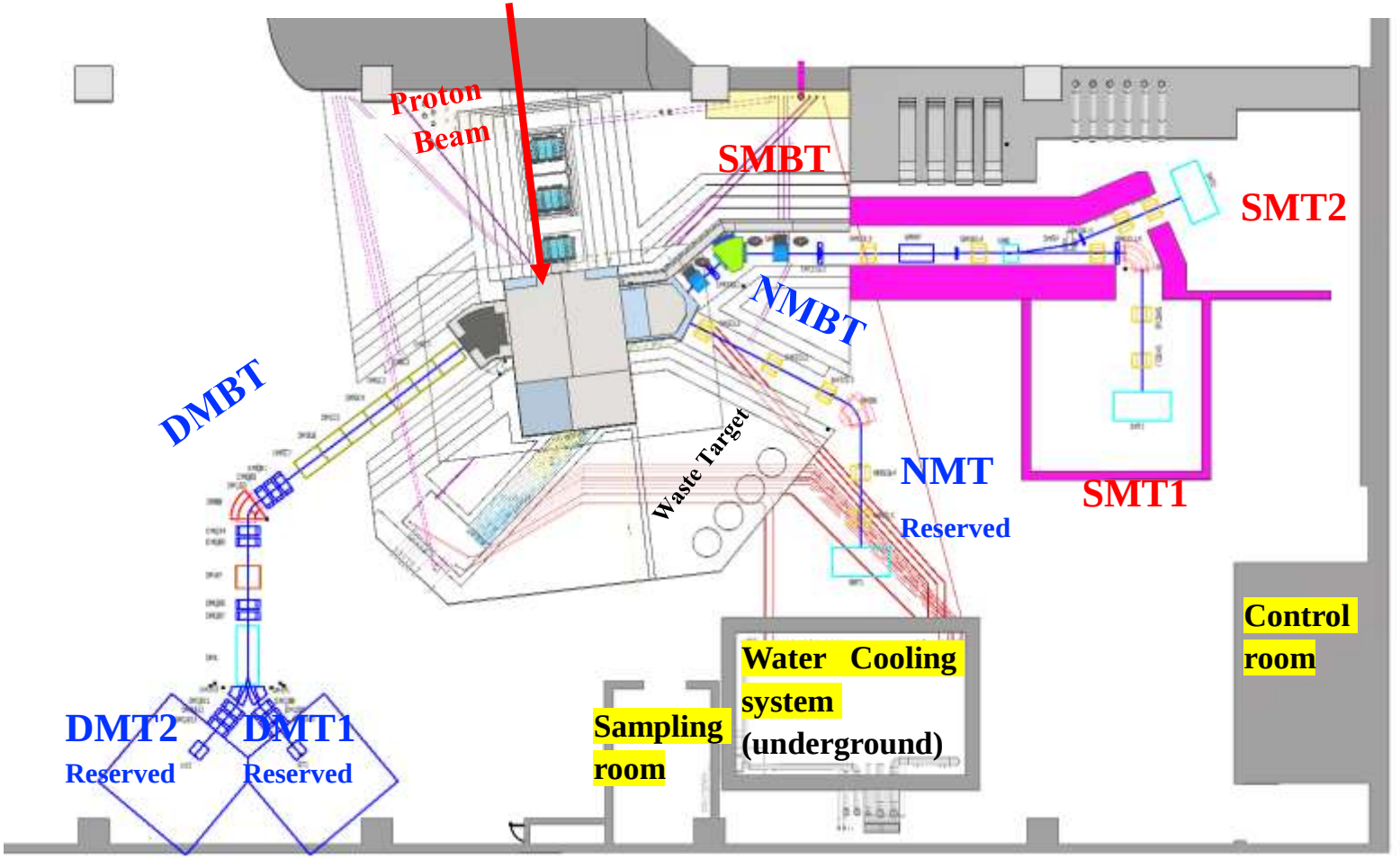
Utilization of High Energy Proton beam



- 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
Beamspot measurement	Pos. resolution	150μm
Flux measurement	Det. size	≥10mm×10mm
	Range	1-10000

Muon Experimental Station



Scientific Goals for Muon Experiments

muSR applications

- Superconductivity
- Magnetism
- Semiconductor
- Biosystems
- …

Muon technology

- Muon moderation
- Muonium production
- Muon acceleration
- Muon detector development
- …

MIXE and others

- Elementary analysis
- Muon imaging
- Single Event Effect
- …

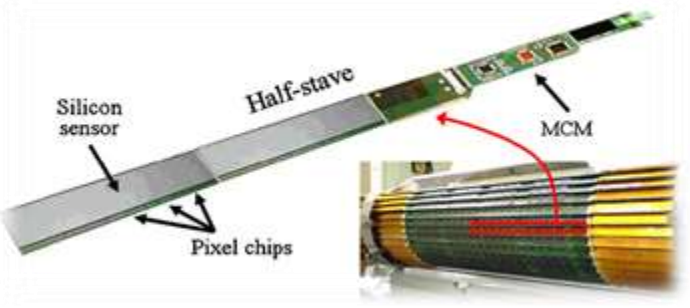
Particle Physics

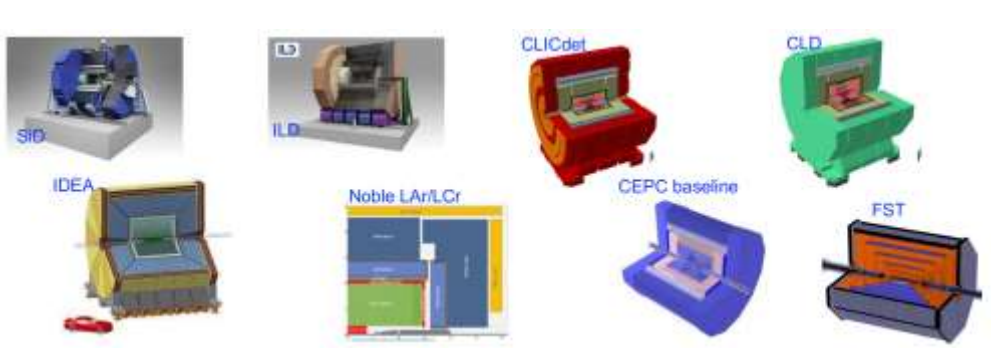
- Muonium physics
- More to be proposed…

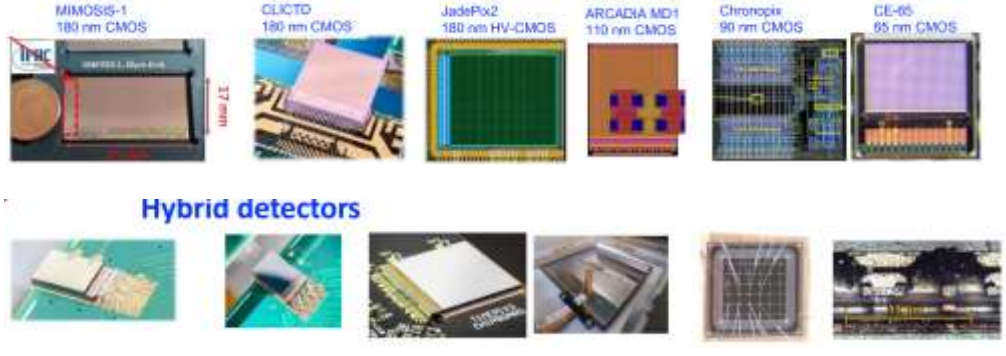
High-energy Proton beam Experimental Station

- Future detector R&D for particle or high-energy physics needs high-energy proton beam for test. CSNS will construct a 0.8-1.6 GeV proton beam test station at CSNS II. The station will implement the test conditions such as high position and energy resolution and radiation damage for the following tests:

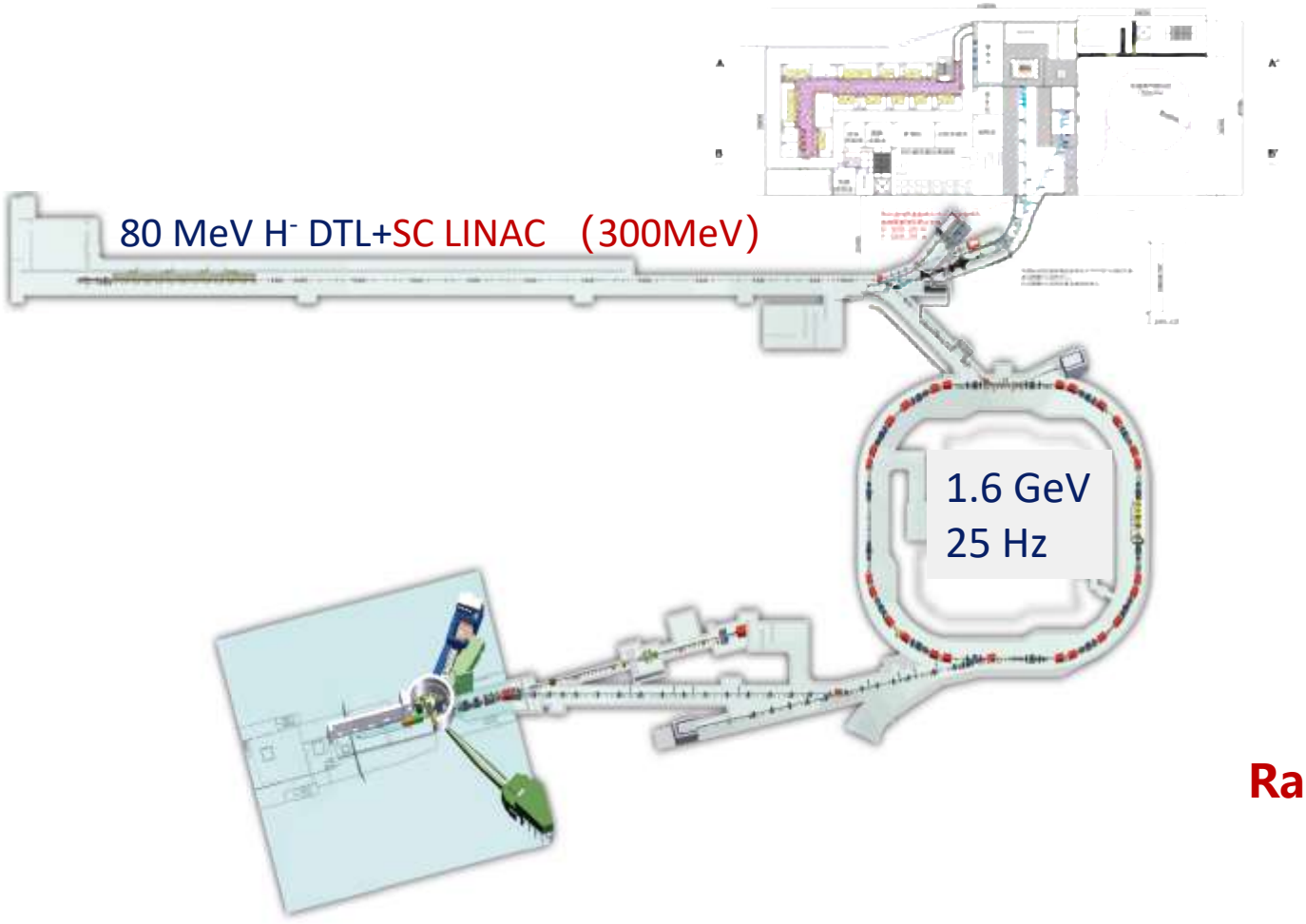
- Detectors for vertex and tracker requirements;
- Calorimeter for particle energy measurement;
- Performance test for fast electronics for particle detectors;
- Radiation damage for detectors and electrics;







Production of α Isotopes using CSNS Linac



- **Rep. rate:**

  25 —— 50Hz

- **Beam energy:**

  80 —— 300MeV

- **Beam power:**

- **5——100kW@25Hz**

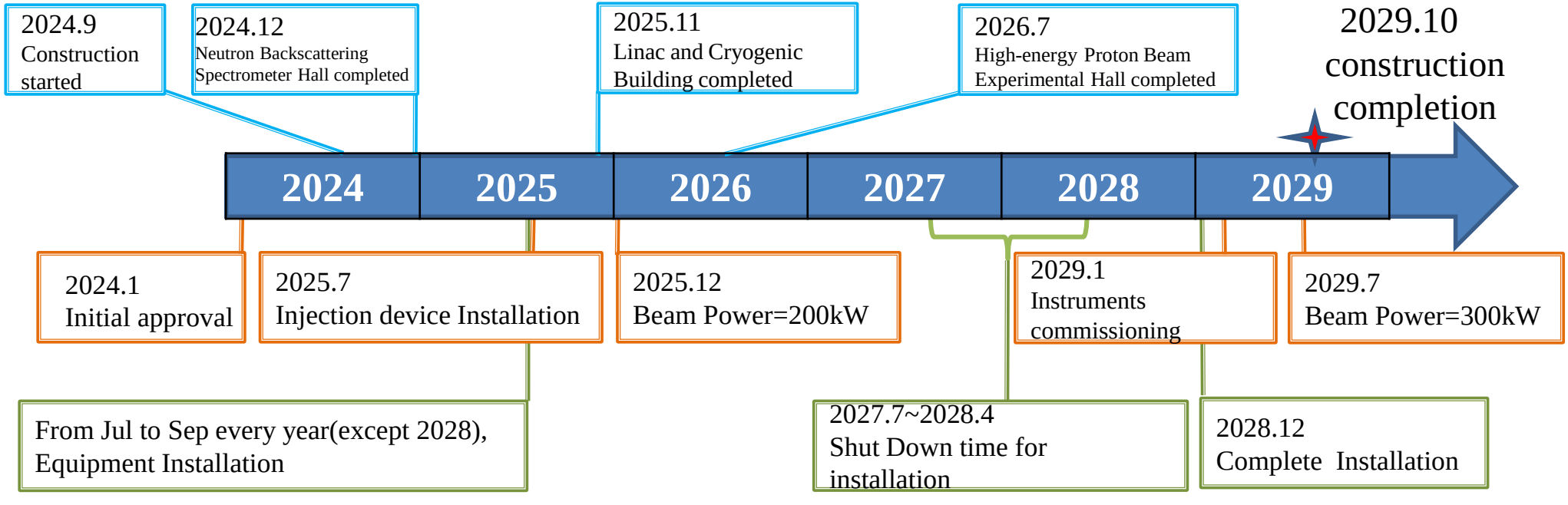
Ra-223、Ac-225、Pb-212，etc

CSNS-II New Buildings

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

Summary

- ✓CSNS (China Spallation Neutron Source) opened to users in 2018. Currently, CSNS operates at 170 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 for your attention!