

Neutron polarization based on polarized ^3He at CSNS

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CSNS PN Group

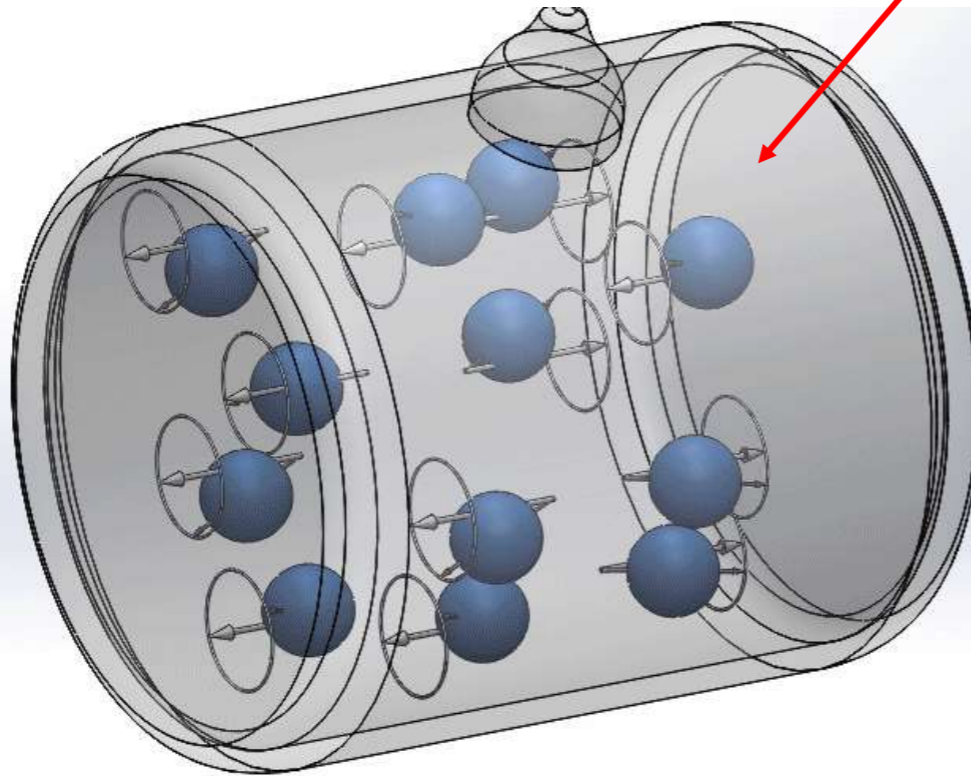
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- 2. Development of Polarized Neutron**
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- 4. Conclusion and Outlook**

1. Introduction

Polarized Neutron through ^3He

Spin Filter



Including system:

Air heating/Discharge

Rb/K/ ^3He filled filter

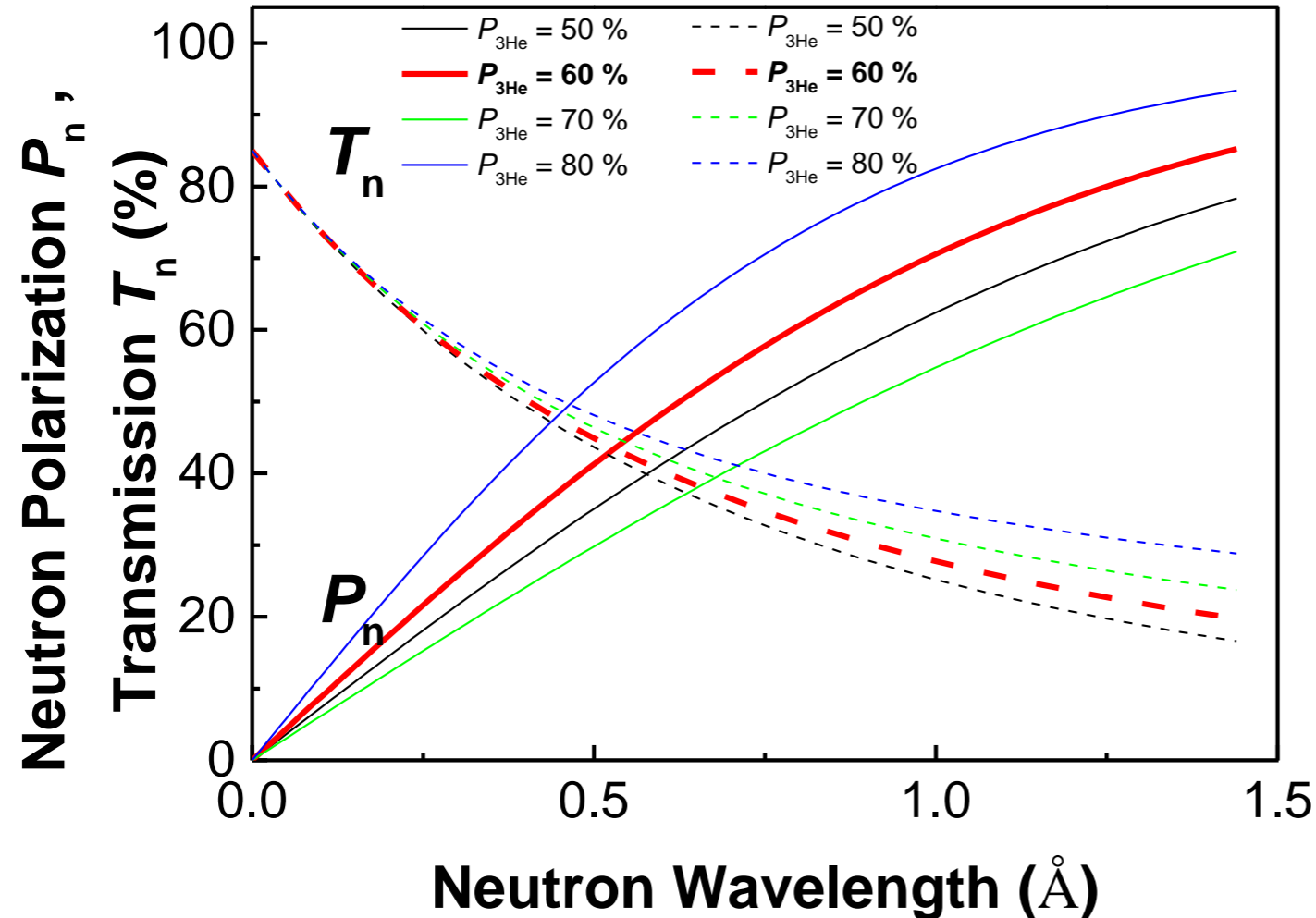
High power pumping laser

Magnetic field

....

1. Introduction

Neutron Polarization VS ^3He Polarization



The relation ship of Neutron polarization and ^3He polarization

For a certain spin filter:

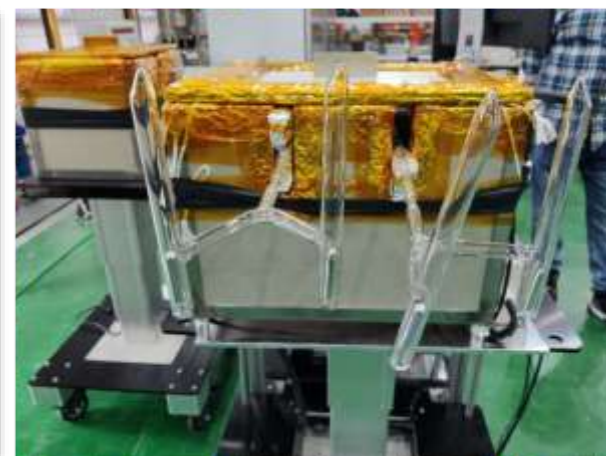
- The higher the ^3He polarization the higher polarization of neutron
- The higher the ^3He polarization the weaker transmission of neutron
- The higher the neutron energy the smaller the cross-section to ^3He

Our goal are **higher ^3He polarization and higher neutron polarization**

2. Development of Polarized Neutron

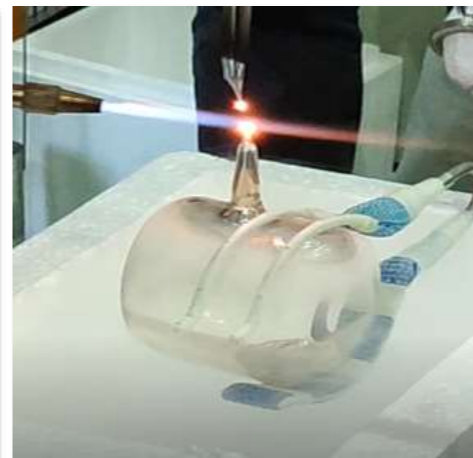
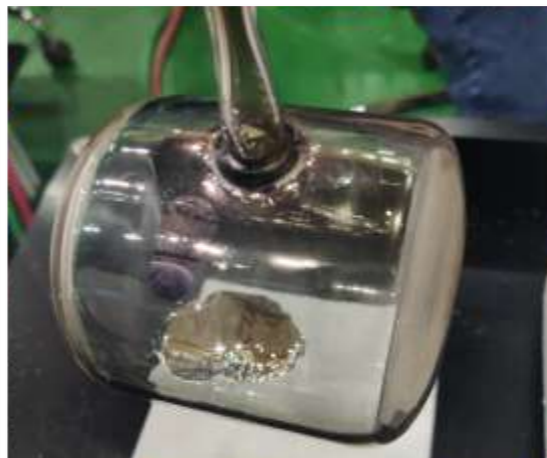
SEOP ^3He spin filter development capability

In-house ^3He cell fabrication



Attach Strings and Clean

Heating and Filling



Tip off

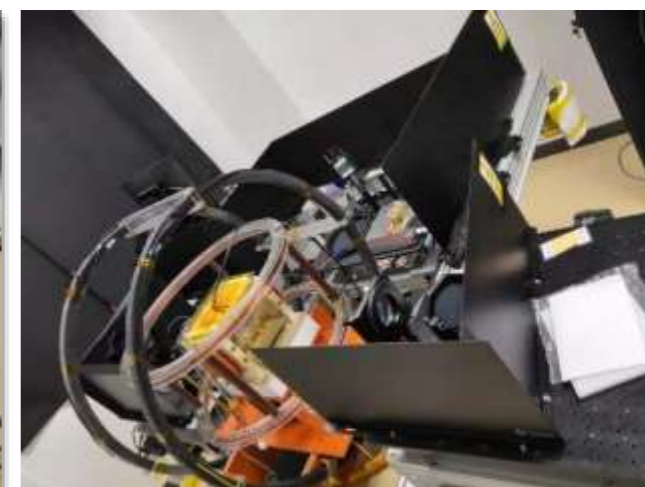
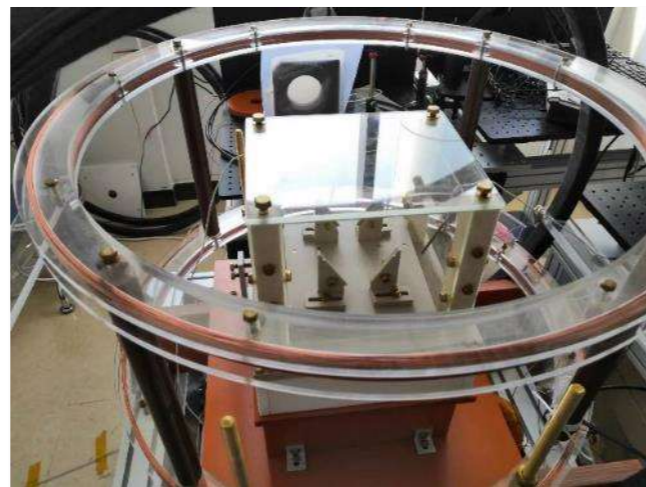
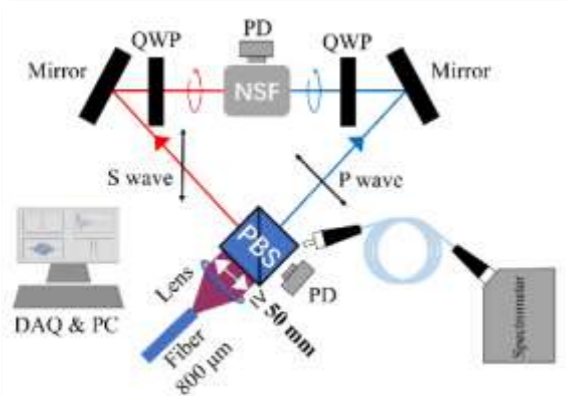
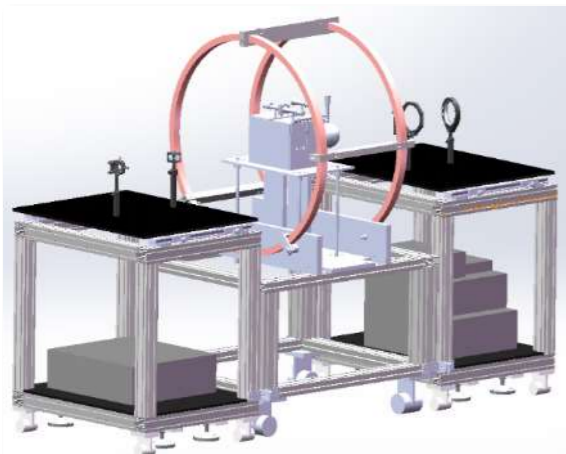


2. Development of Polarized Neutron

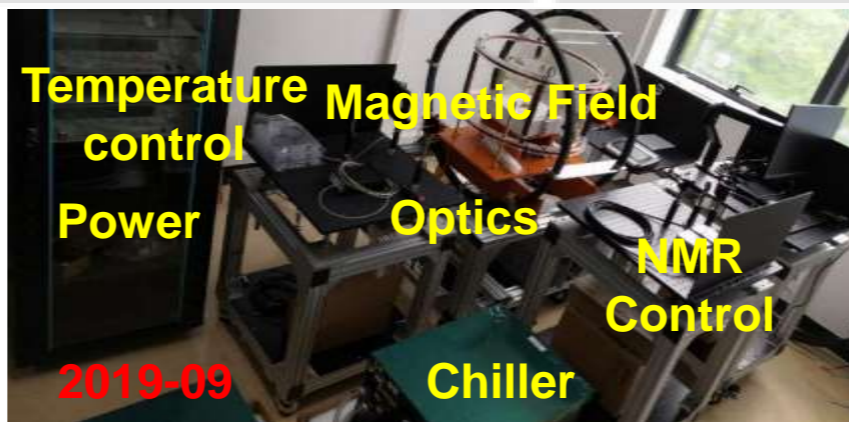
Off-situ ^3He Pumping Station

Functions:

- High Temperature
- High Power Laser
- Uniform Magnetic Field
- NMR Monitoring



First Generation Design



2. Development of Polarized Neutron

Off-situ System

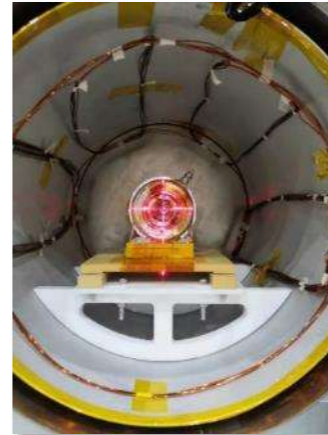
- ✓ ^3He polarization $\geq 77\%$
- ✓ ^3He life time ≥ 200 hrs
- ✓ Polarization of 4\AA $> 99\%$



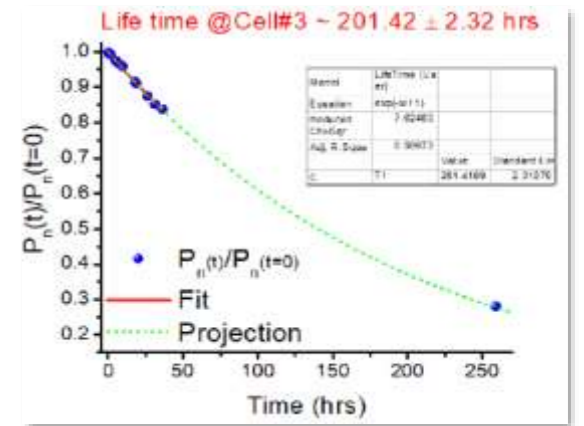
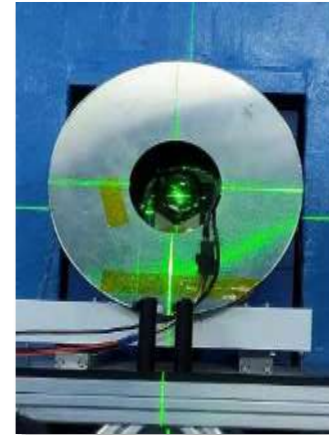
Initial Operation



Off-situ system



Alinement



24hrs Monitoring

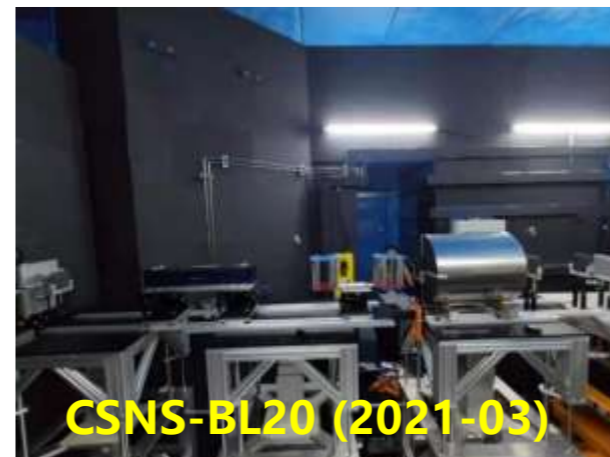


Running



CSNS-BL20 (2021-01)

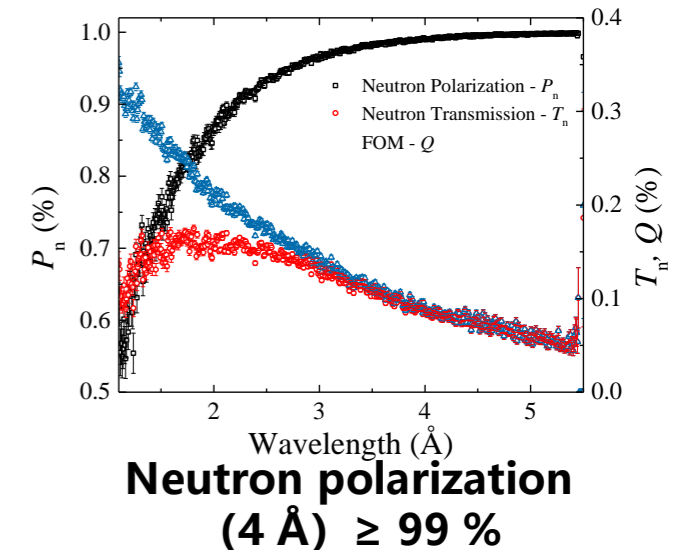
Install in the Beamline



CSNS-BL20 (2021-03)

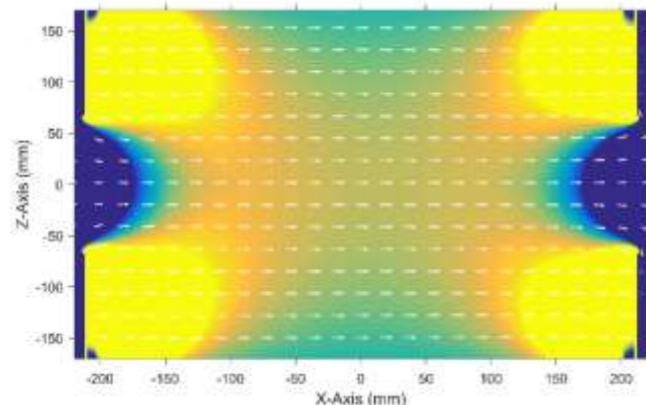
Examined By Neutron

Life time of $^3\text{He} \geq 200$ hrs

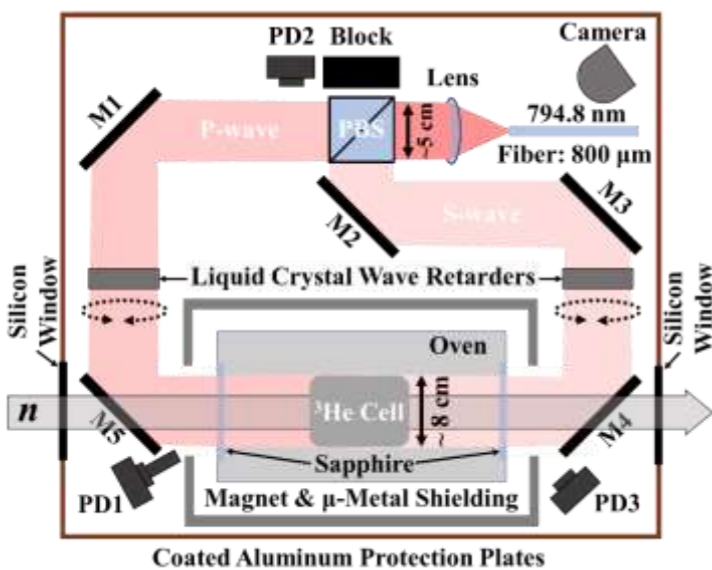


2. Development of Polarized Neutron

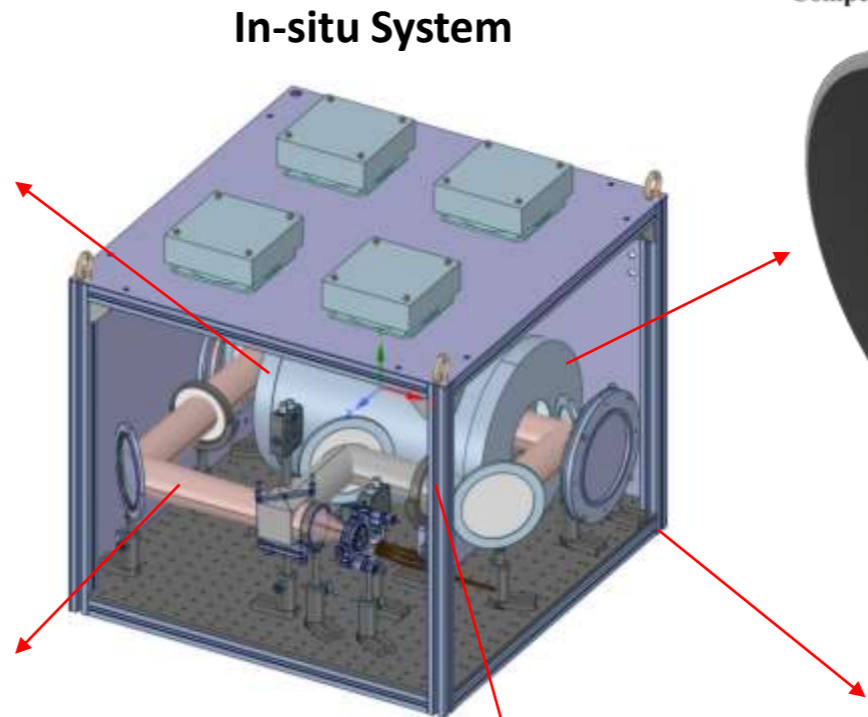
In-situ System: Pumping system and spin filter



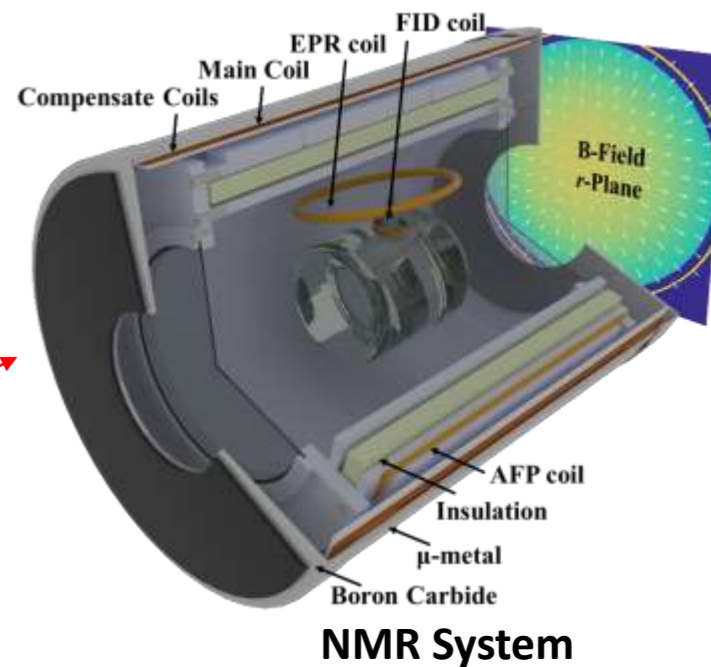
Magnetic field



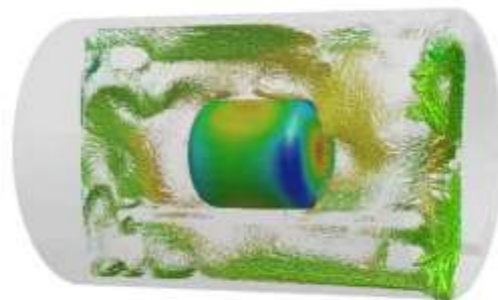
Optical Setup



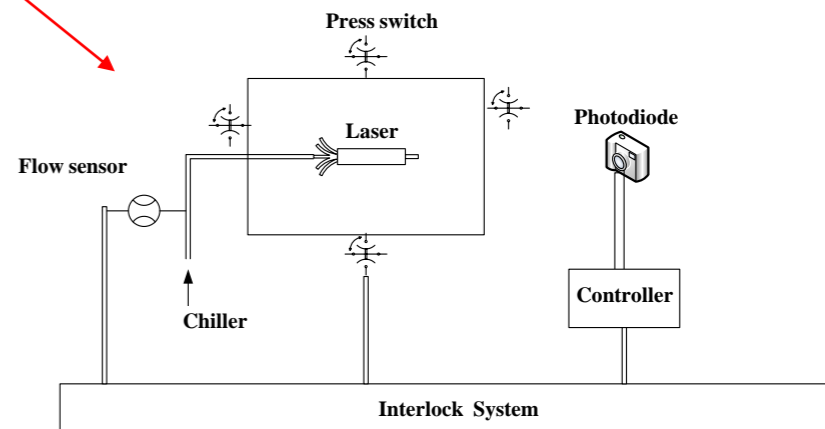
In-situ System



NMR System



Heating Simulation



Safety Interlock

2. Development of Polarized Neutron

In-situ System Integrated the system together and measured online

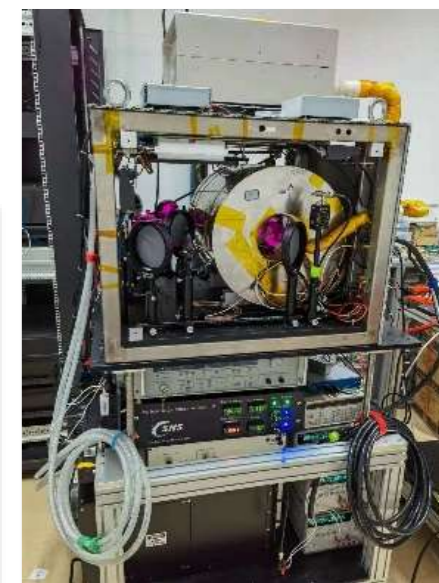
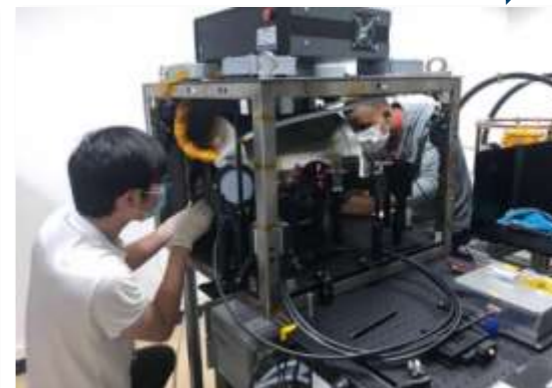
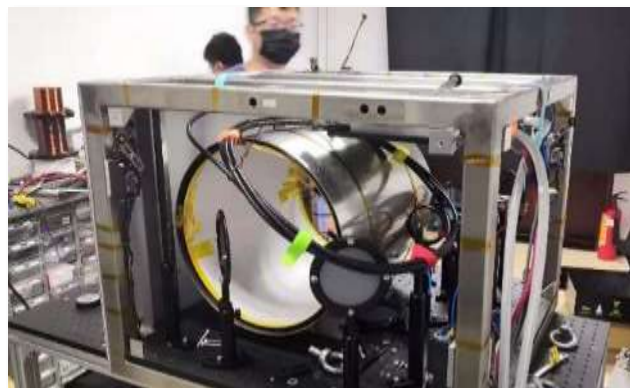
Pumping station Magnetic field Spin filter ...

Off-line running

Frame

Install ^3He

Optics + Heating Oven



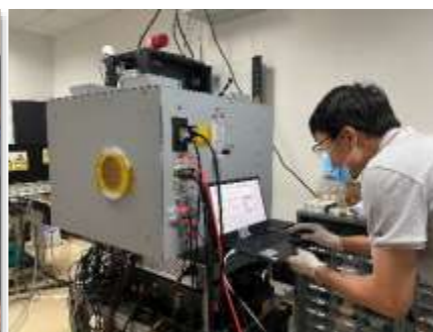
Heating testing

upgrade

Pre-running

Aliment on beamline

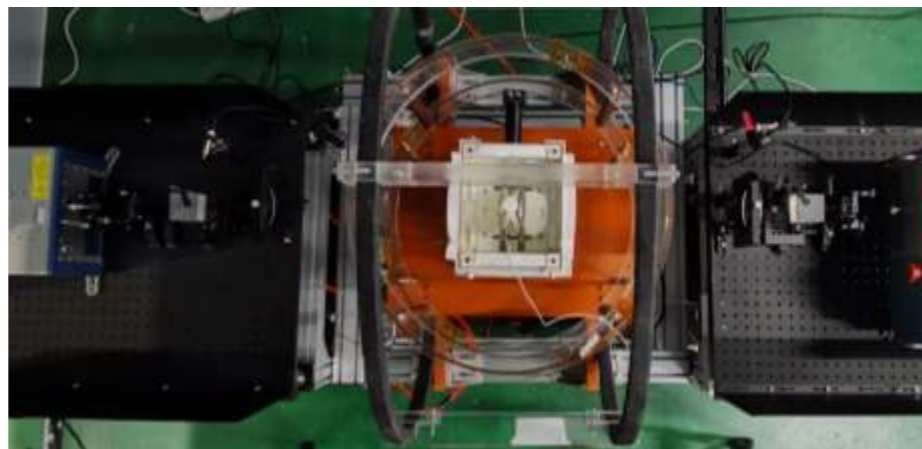
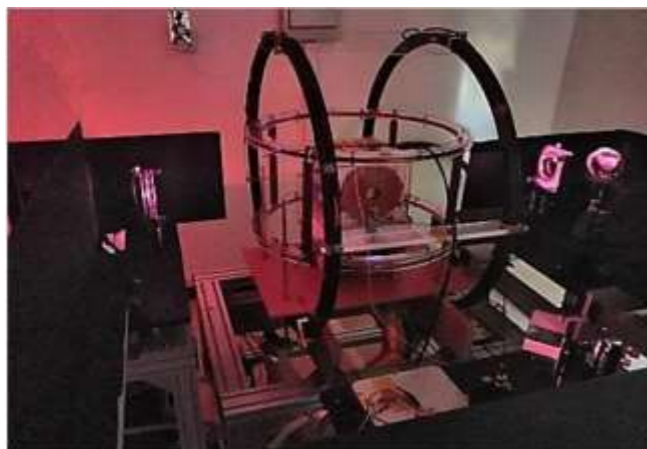
Continuous running



2. Development of Polarized Neutron

^3He System

2 off-situ station + 2 In-situ system



Pumping station: Cell selection & off-situ



In-situ system



First Generation

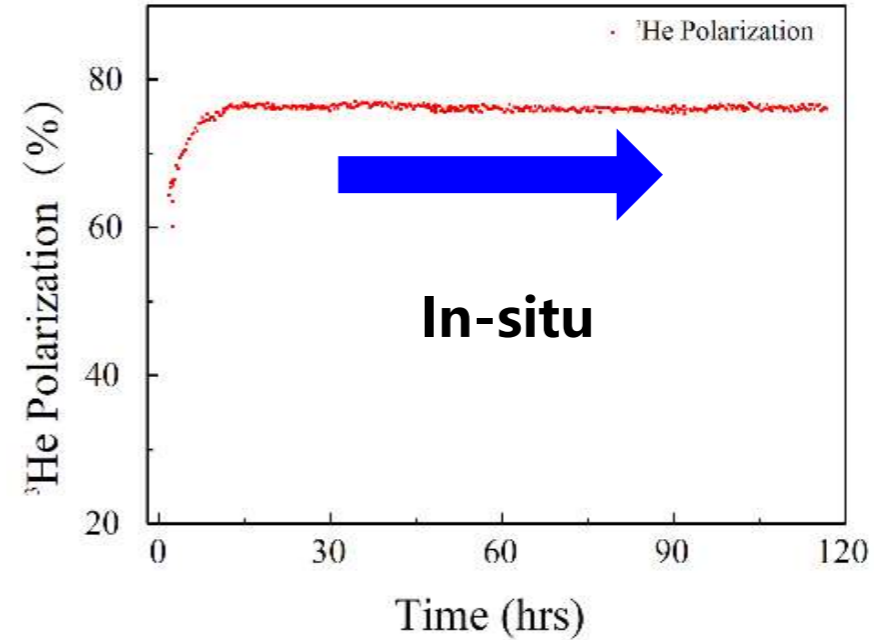
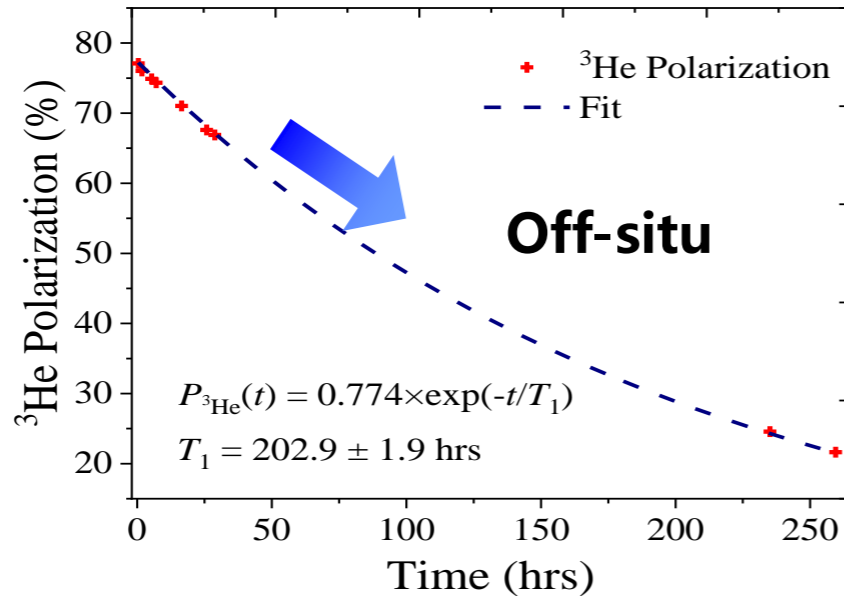


Upgrade



2. Development of Polarized Neutron

Parameters of ³He Spin Filter System

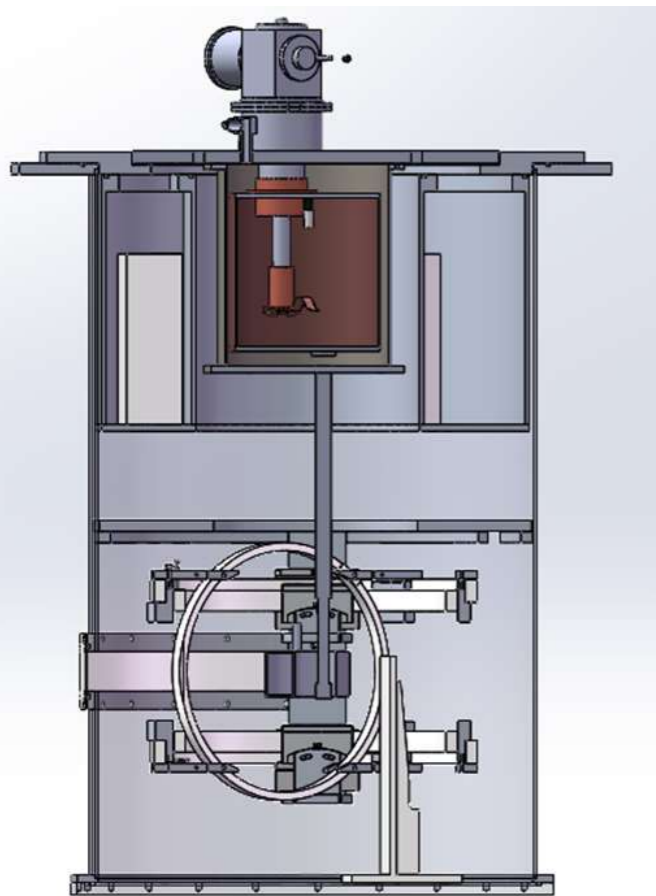


System Type	System Length	Cell Length	Cell Pressure	³ He Polarization	Lifetime	Neutron Polarization (2 Å)	Neutron Transmission (2 Å)
Off-situ1	< 40 cm	≥ 8 cm	≥ 1 bar	40%-75%	≥ 200 h	≥ 80%	≥ 30%
Off-situ2	< 40 cm	≥ 8 cm	≥ 1 bar	50%-75%	≥ 200 h	≥ 80%	≥ 30%
In-situ1	< 70 cm	≥ 10 cm	≥ 1.5 bar	≥ 70%	--	≥ 85%	≥ 20%
In-situ2	< 55 cm	≥ 8 cm	≥ 2.5 bar	≥ 60%	--	≥ 90%	≥ 15%

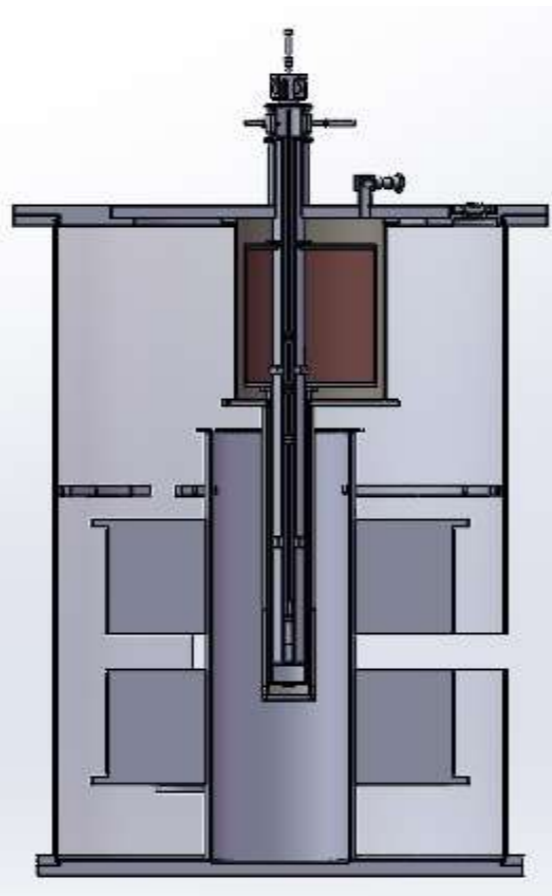
2. Development of Polarized Neutron

Development of Wide-Angle ^3He Spin Filter System

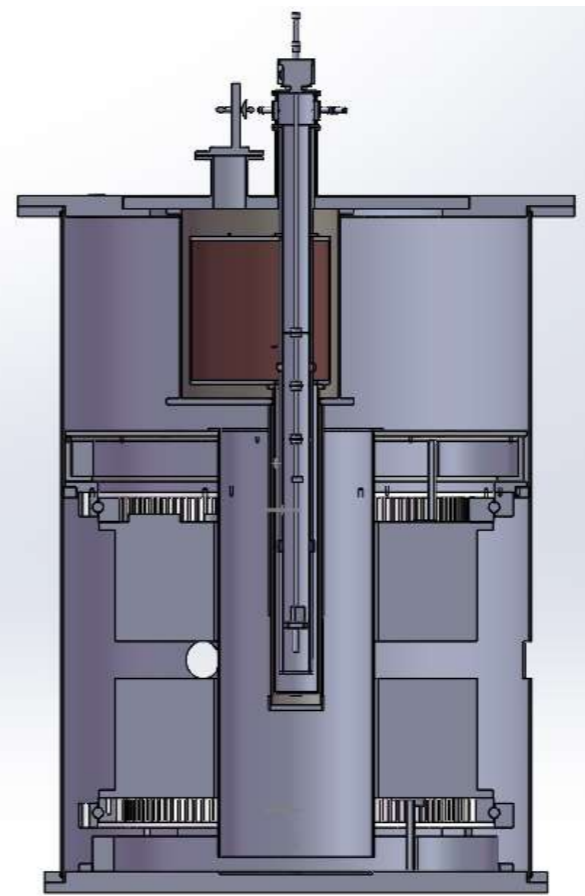
1D



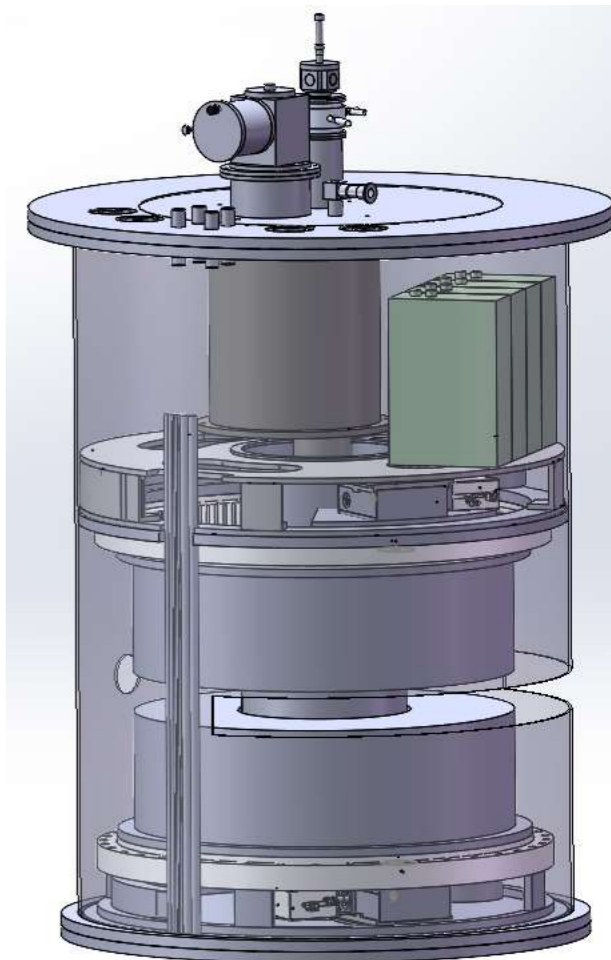
2D



3D



3D

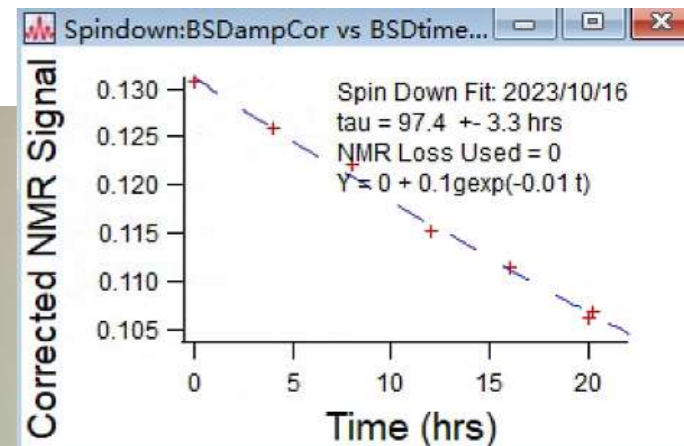
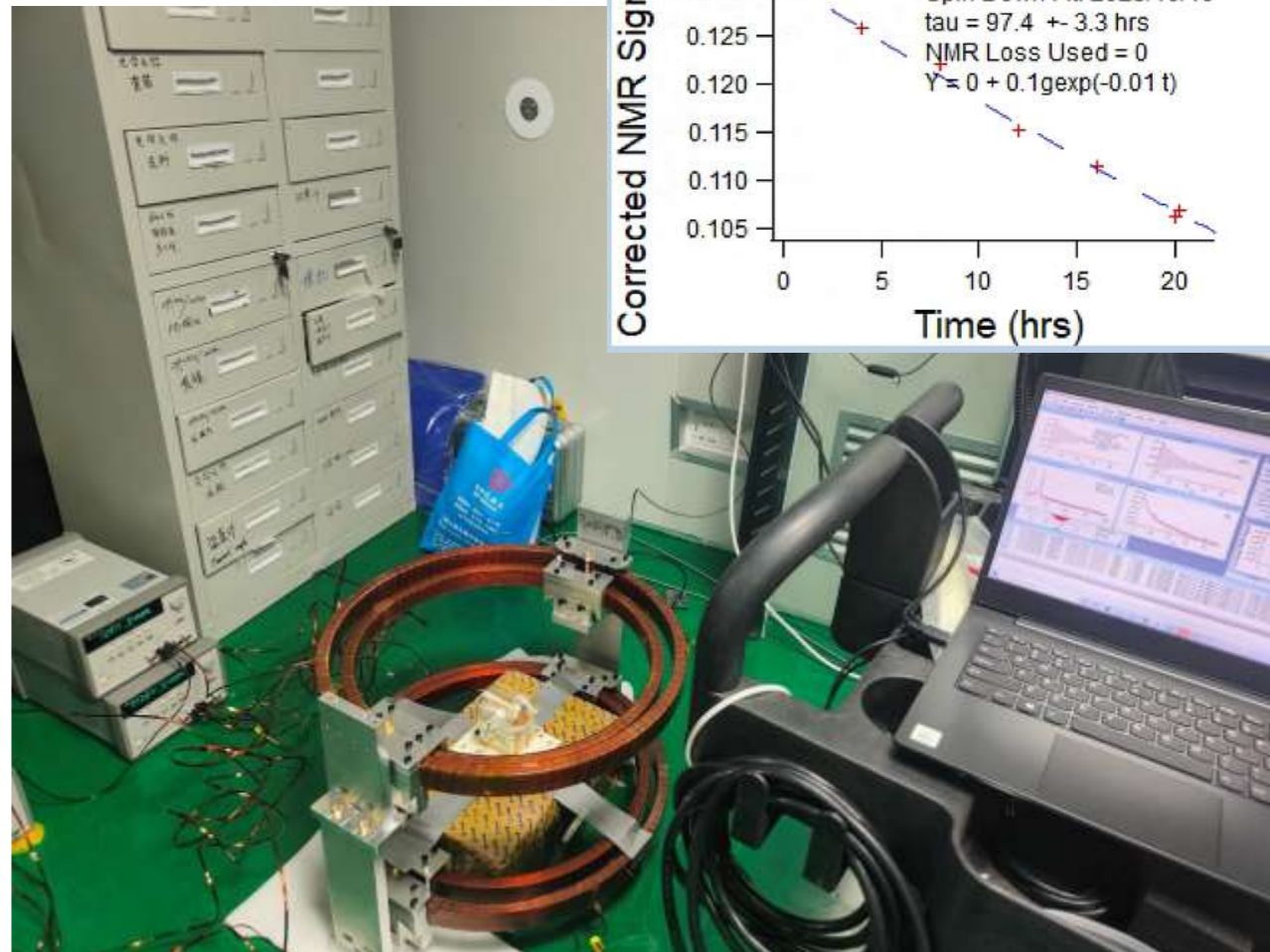
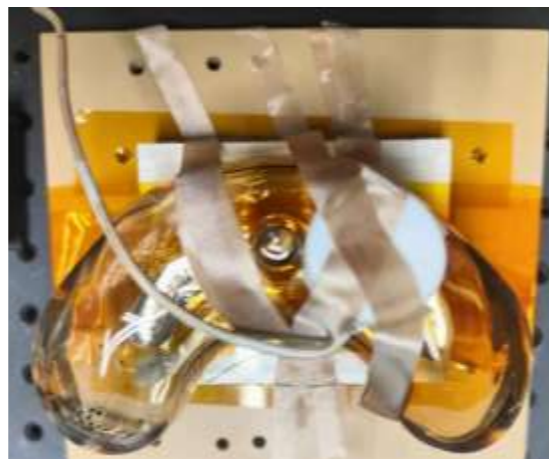
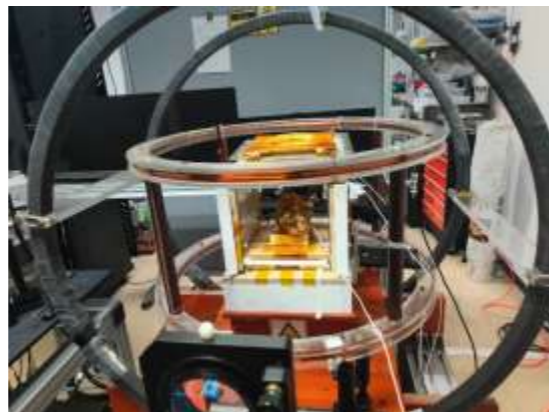
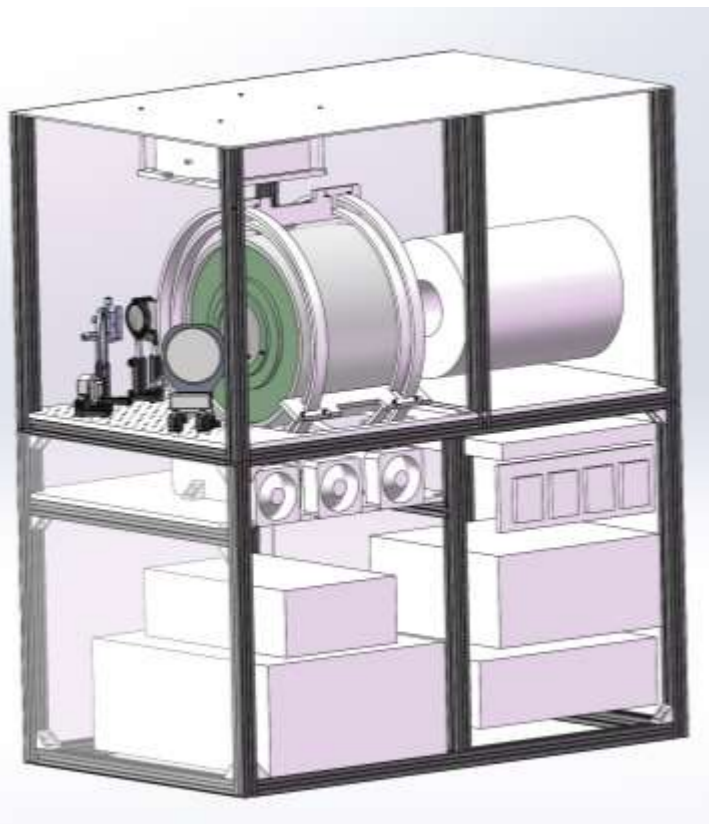


Road Map

2. Development of Polarized Neutron

Development of Wide-Angle ^3He Spin Filter System

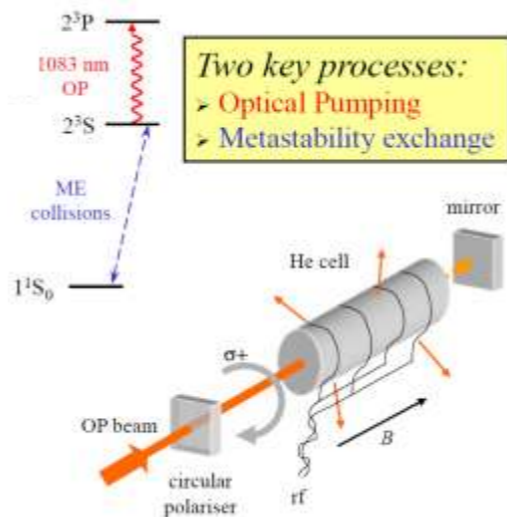
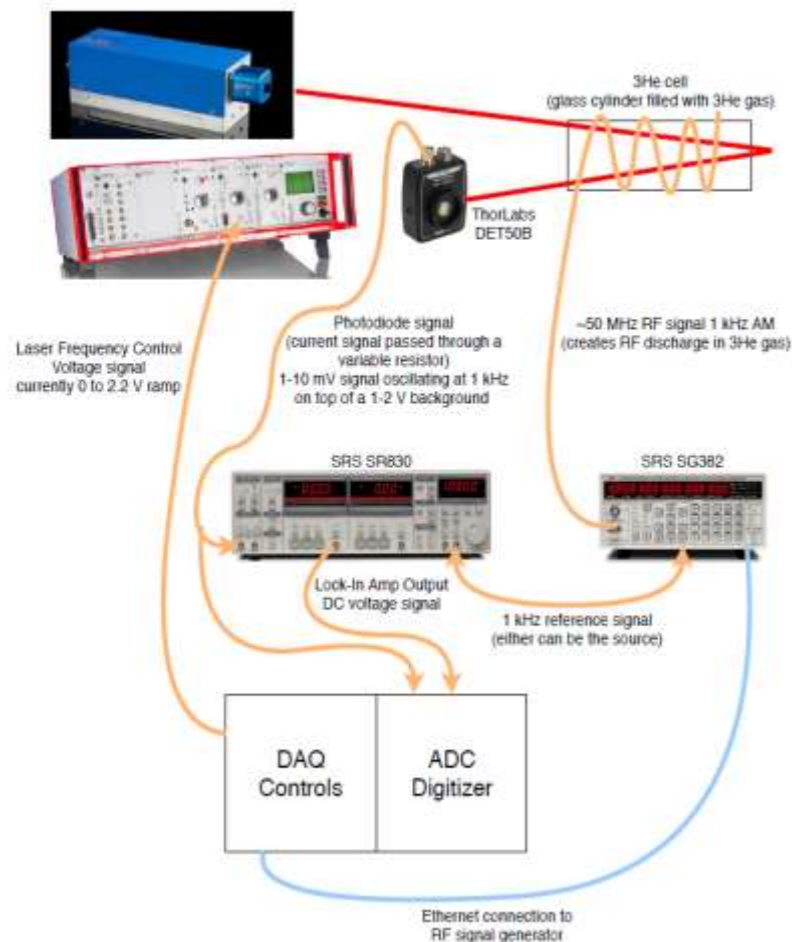
Wide-Angle Pumping Station



2. Development of Polarized Neutron

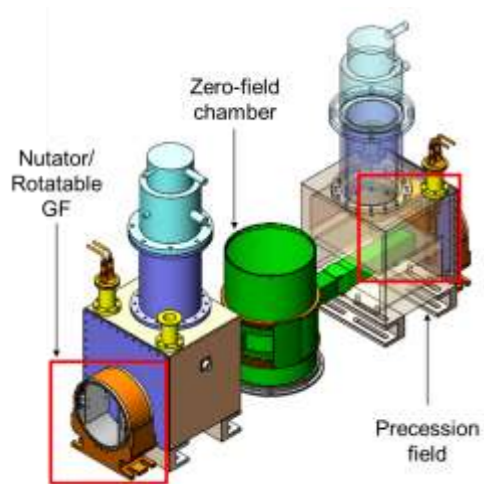
Development of Low Field MEOP system

3He Polarimeter Controls System

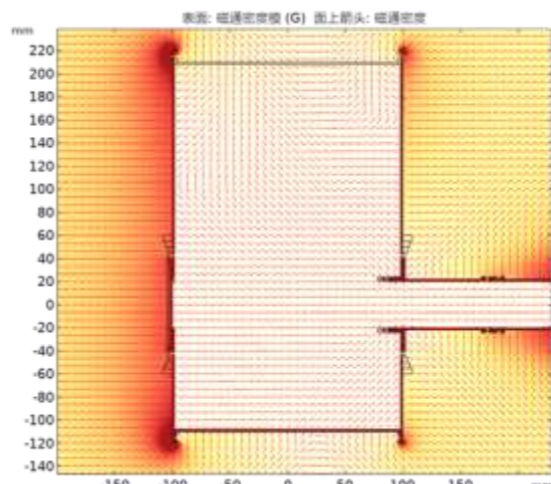


2. Development of Polarized Neutron

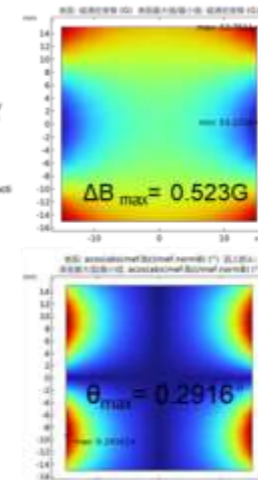
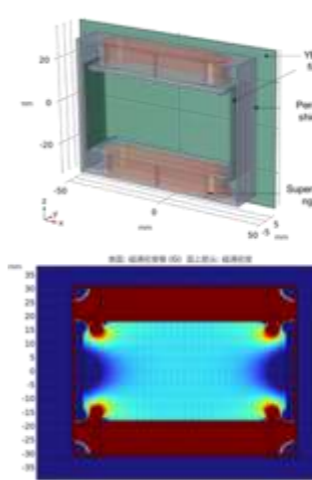
Current Status of Neutron Spin Control System



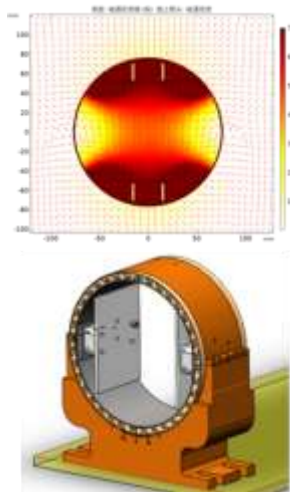
Overall design



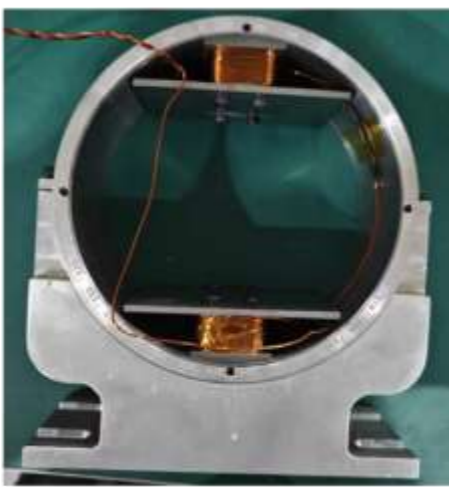
Rotatable ZFC



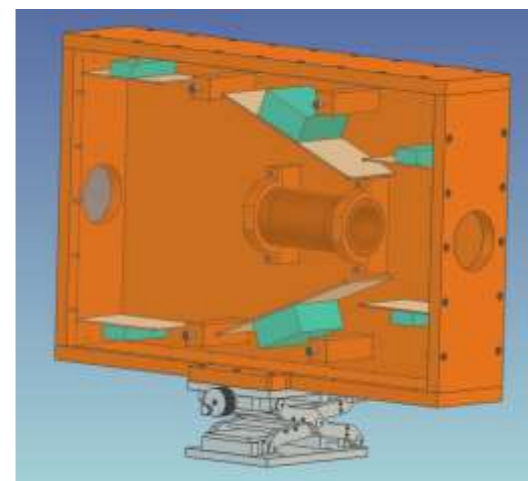
Precession field design



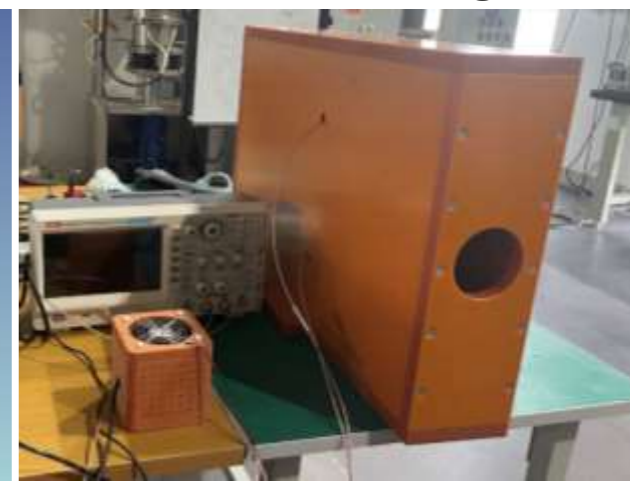
Nutator



Cryo-flipper

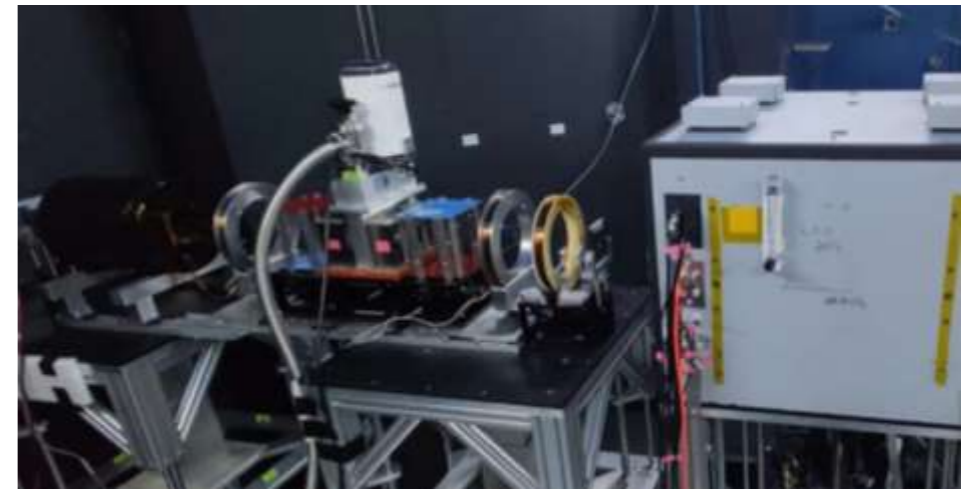
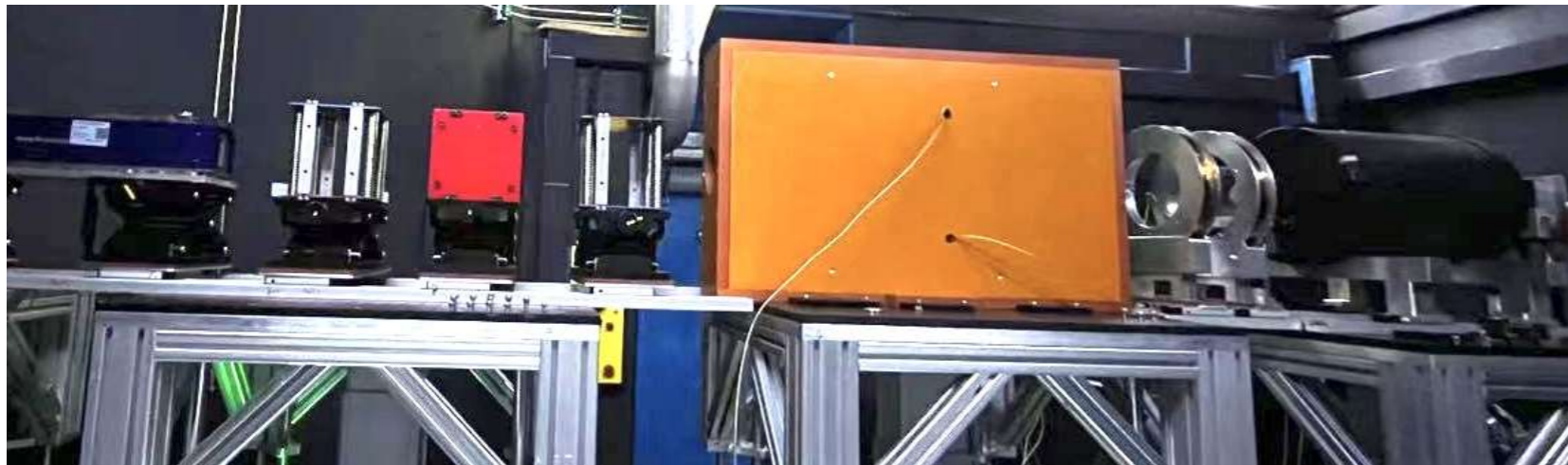
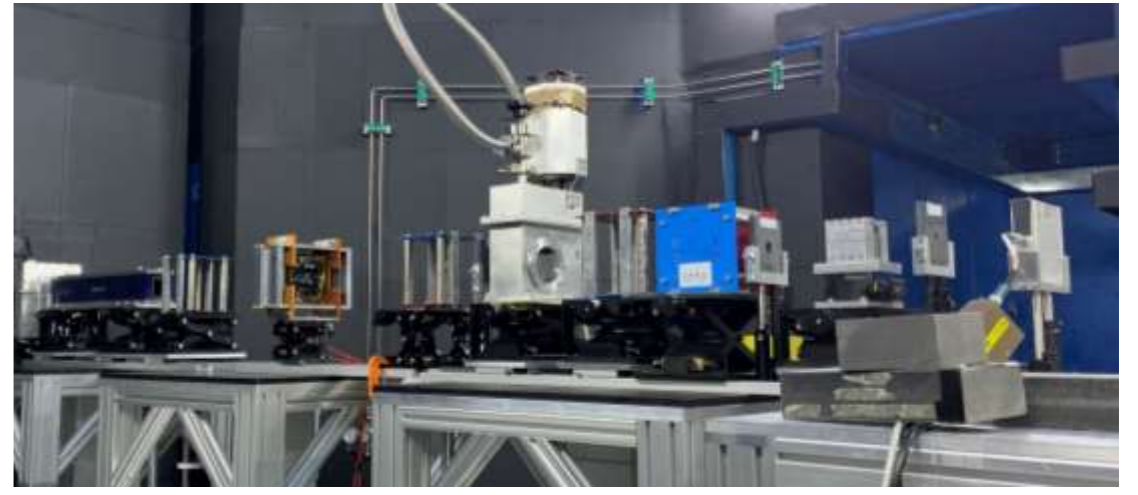


RF flipper



3. Commission on Beamline @ BL20

^3He system & Neutron Spin Control System on beam line

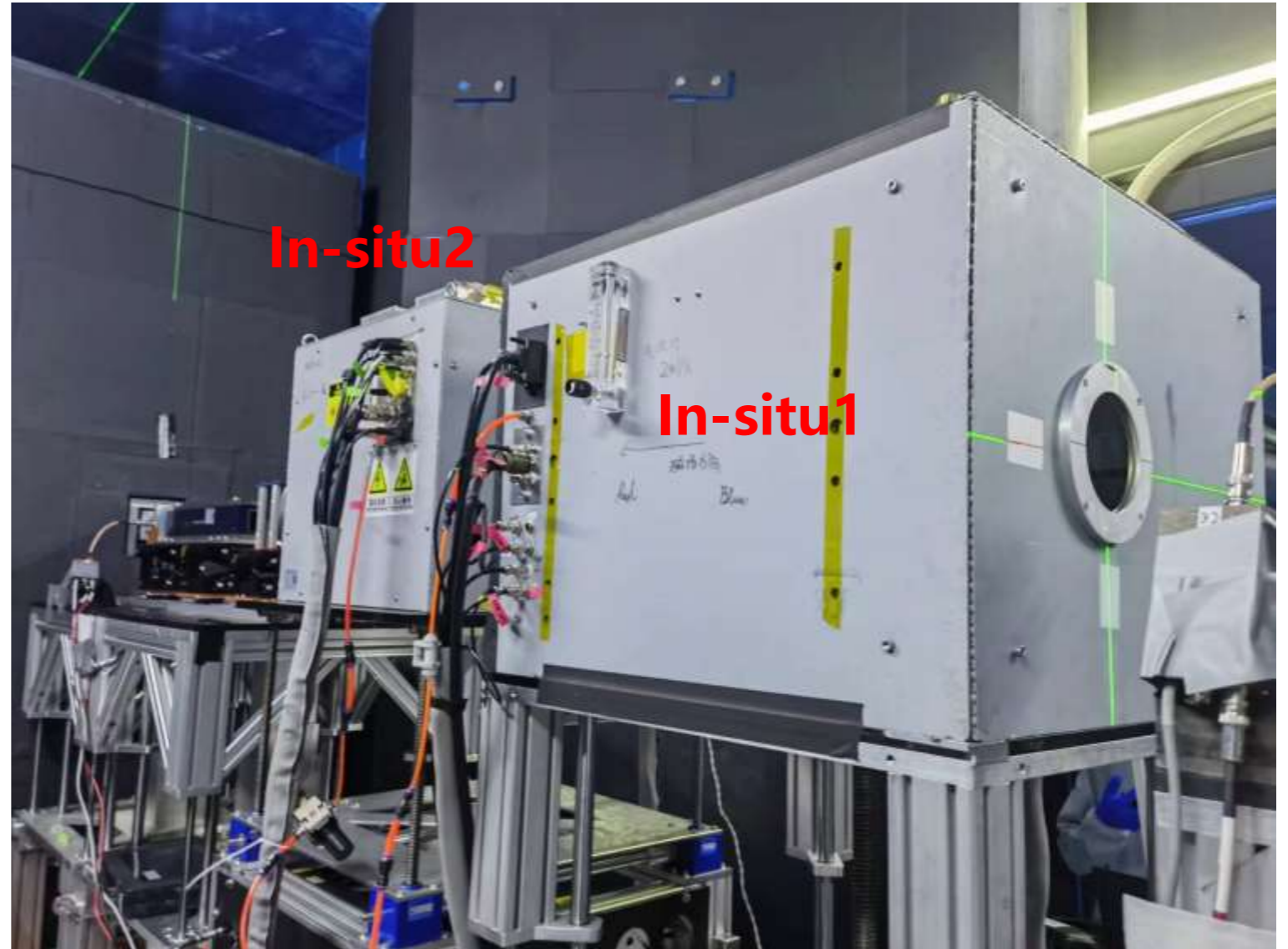
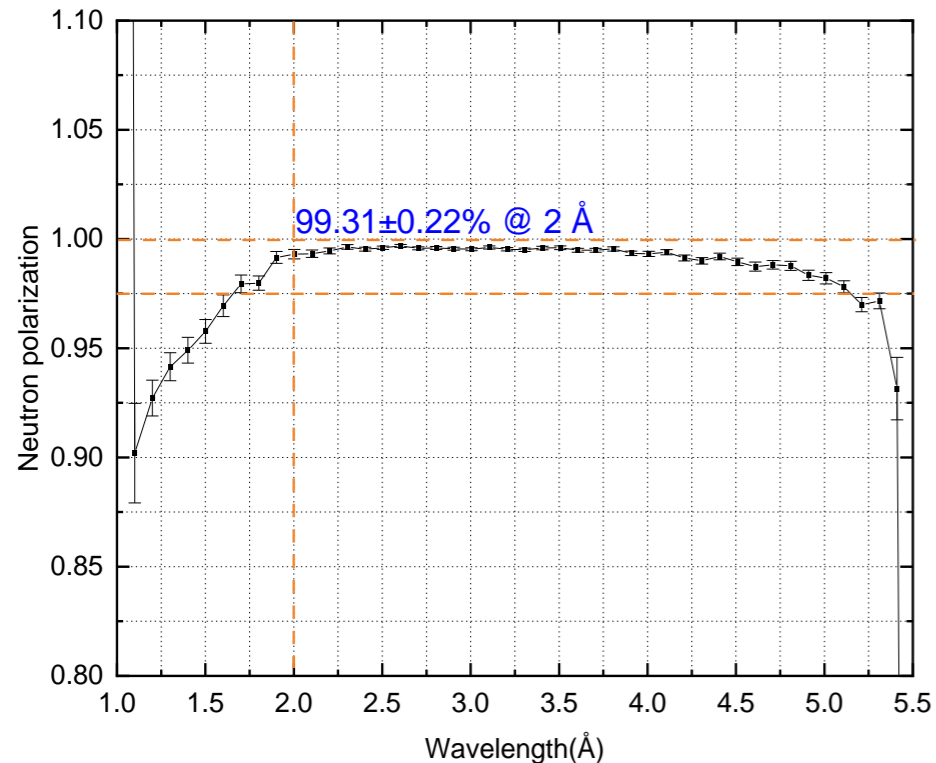


3. Commission on Beamline @ BL20

^3He system

Two system combined to measure the polarization efficiency at BL20-CSNS

The latest data shows that we can achieve up to 99% polarization at 2 Å



3. Commission on Beamline @ BL2

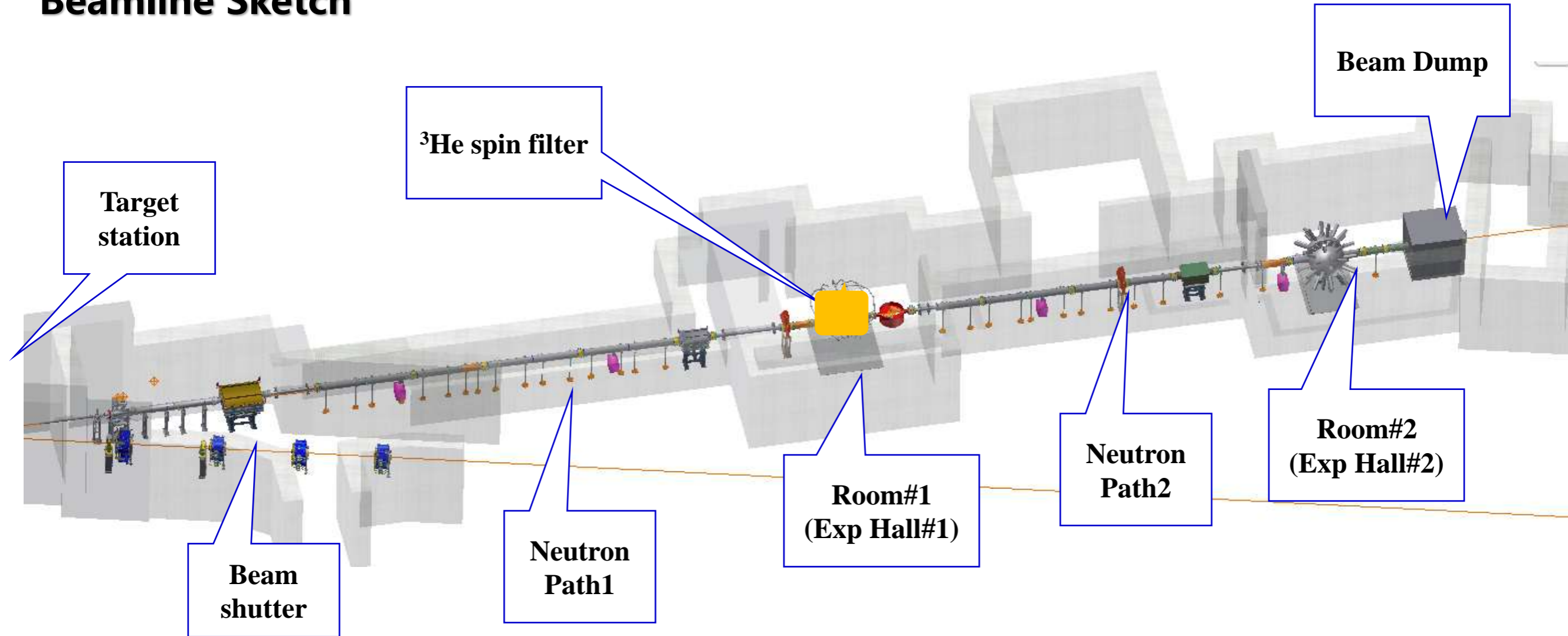
^3He system

In-situ2 system adapted to Multiple Function Reflectometer (BL2-CSNS)



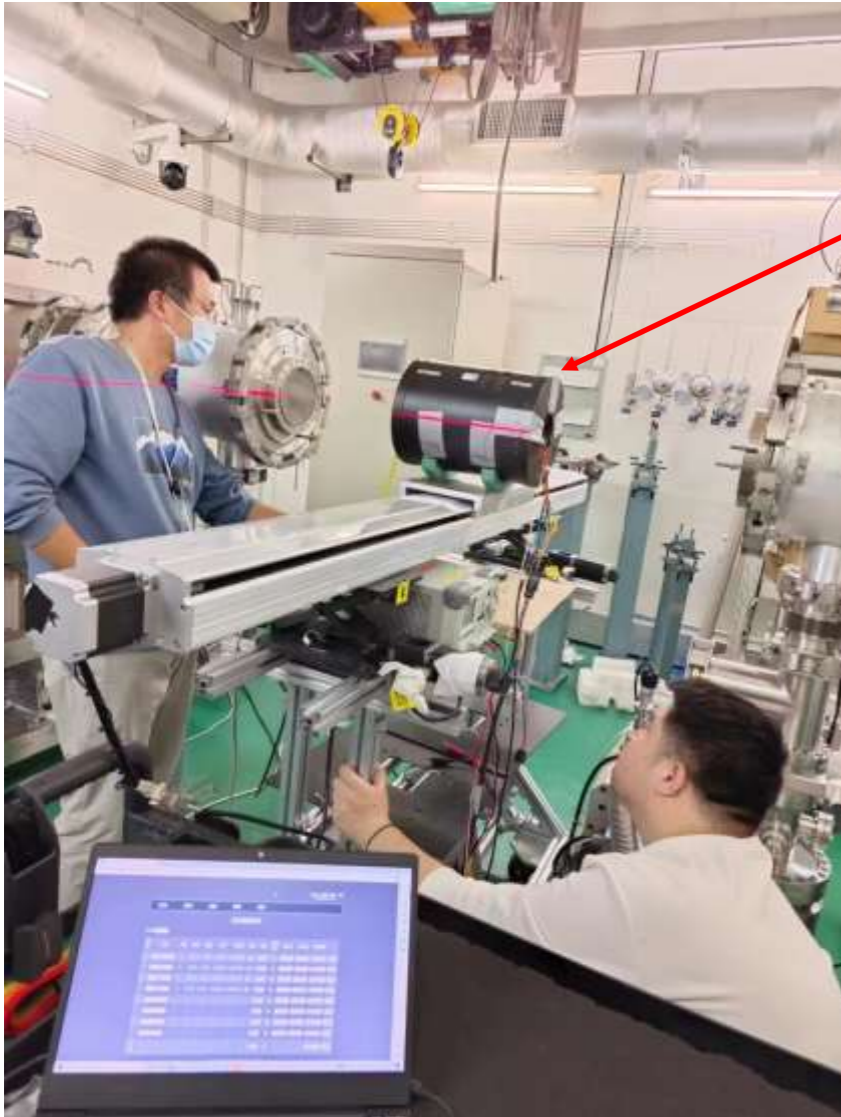
3. Commission on Beamline @ BN

Beamline Sketch

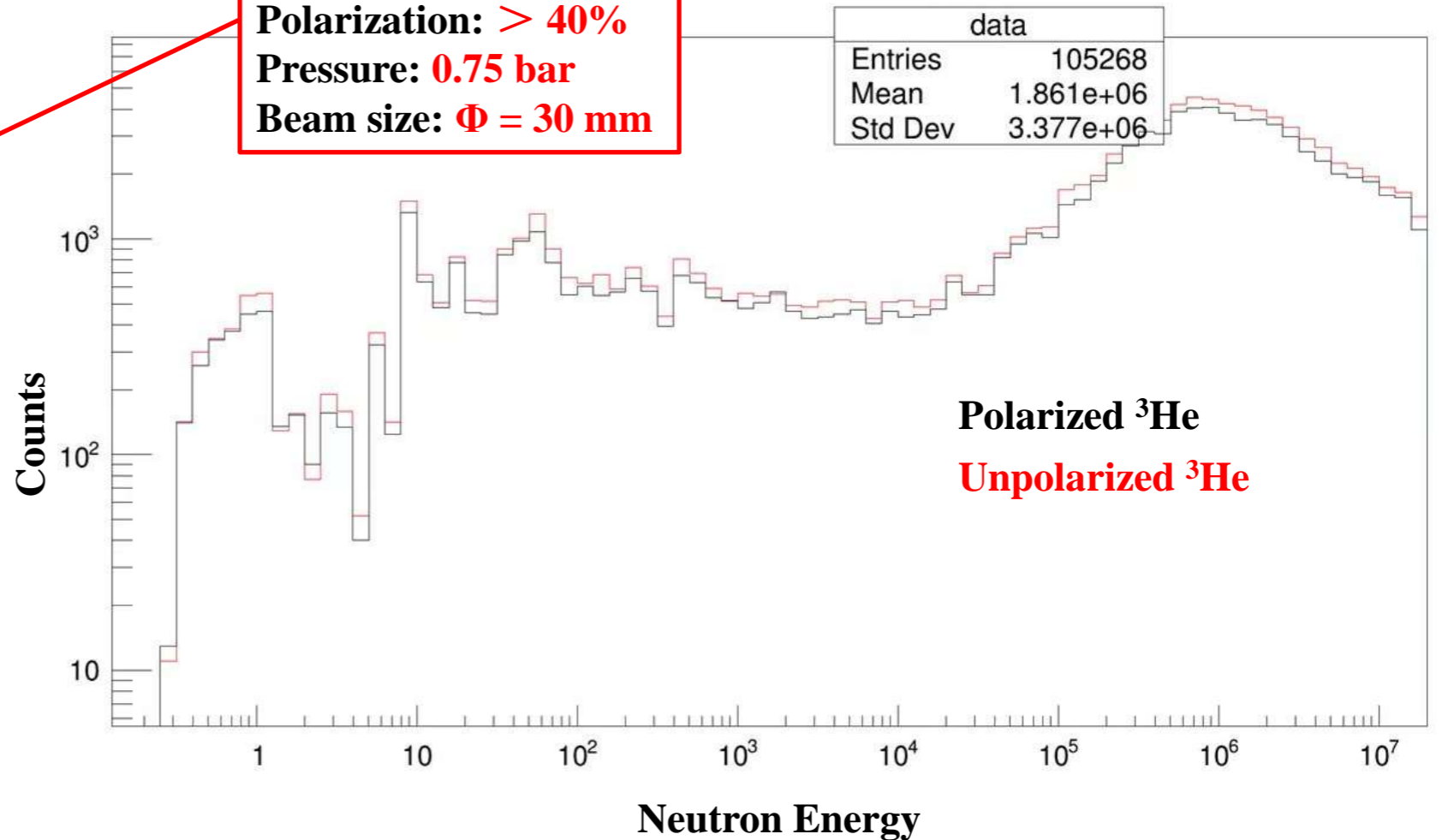


3. Commission on Beamline @ BN

Pre-Experiment: off-situ

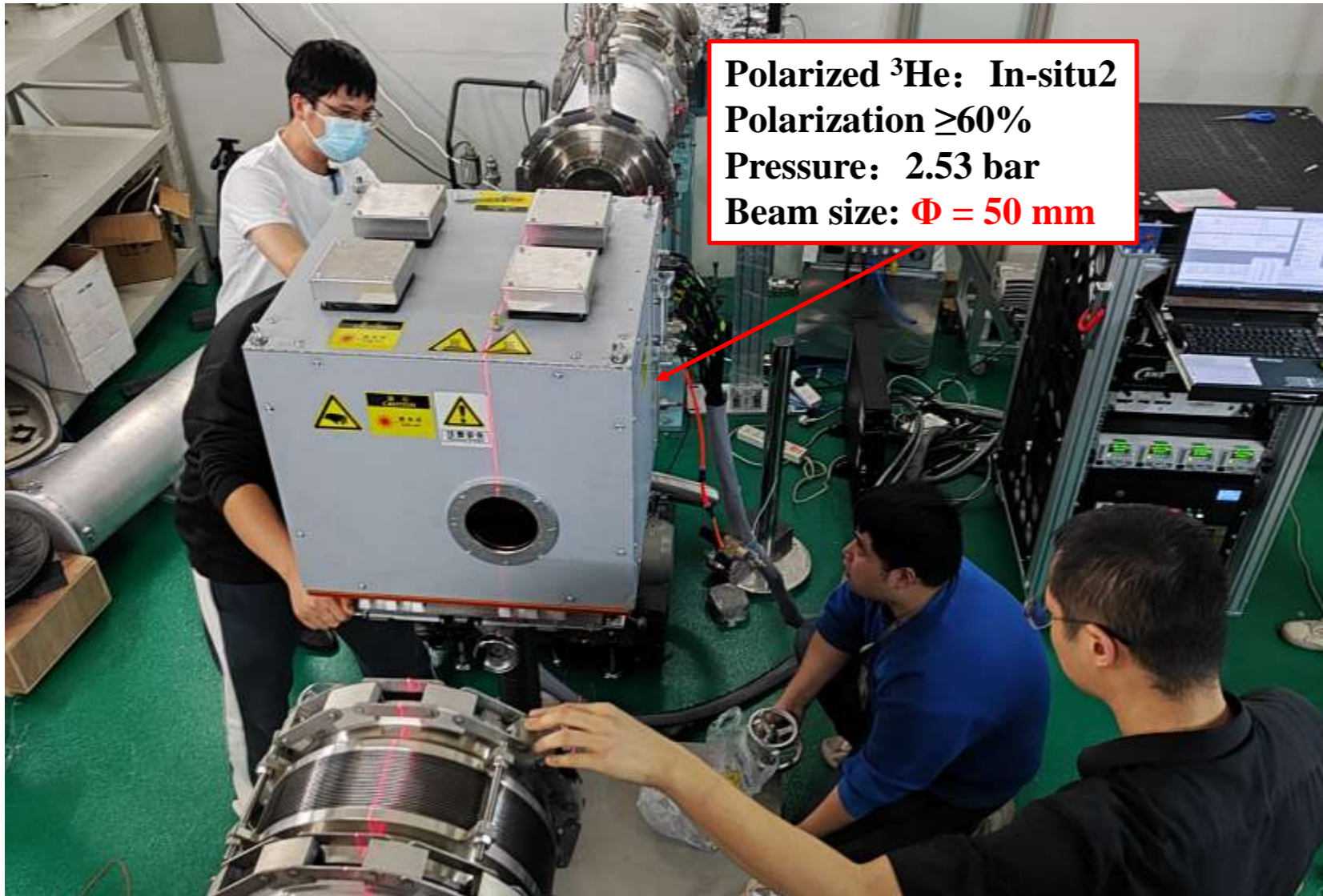


Polarized ^3He : Off-situ
Lifetime: ≥ 200 hrs
Polarization: $> 40\%$
Pressure: **0.75 bar**
Beam size: $\Phi = 30$ mm

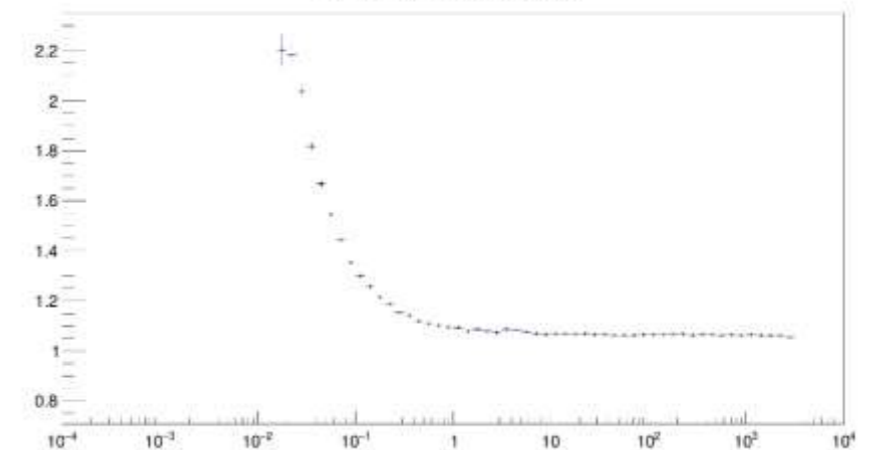
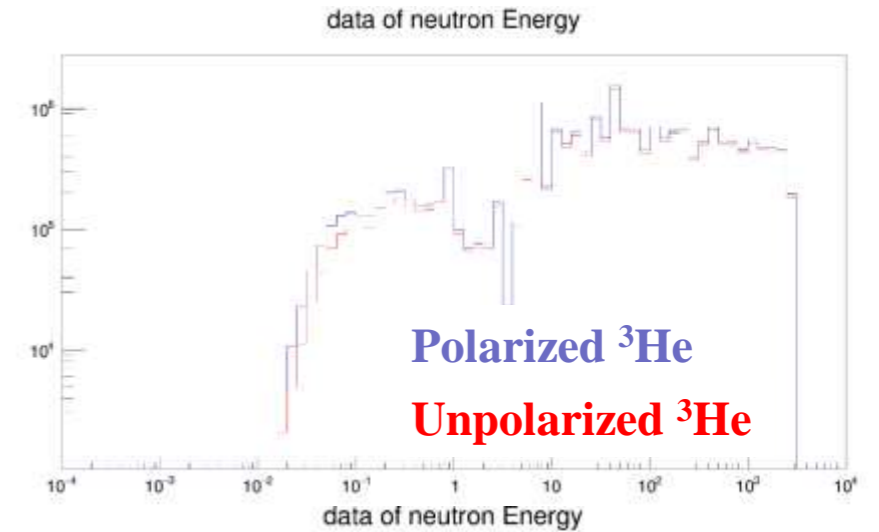


3. Commission on Beamline @ BN

Upgrade Experiment: In-situ



Transmission of polarized & unpolarized ^3He



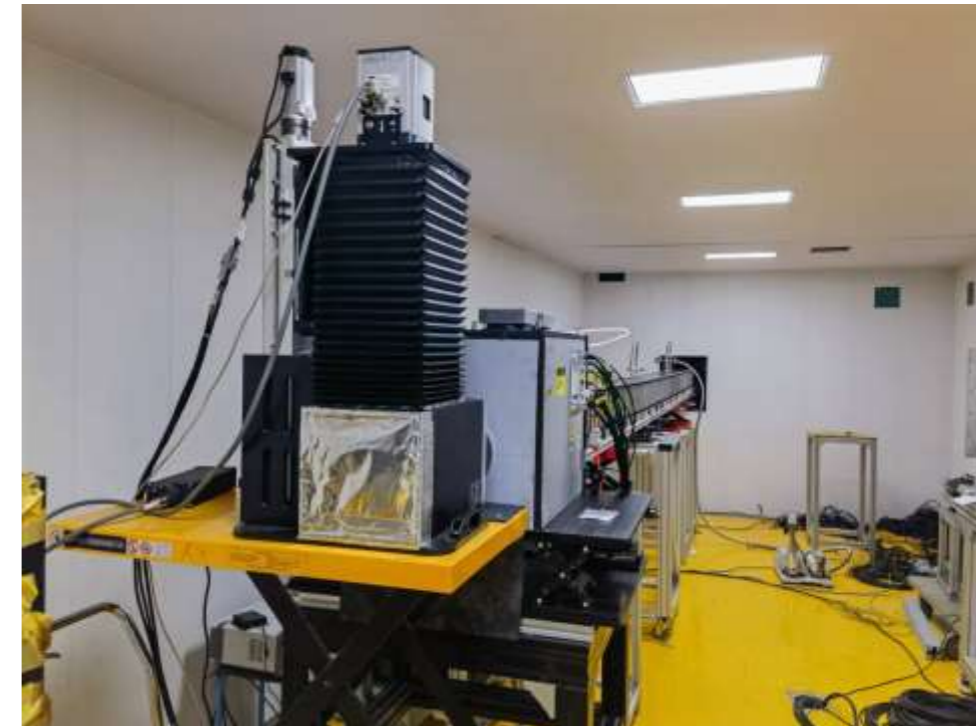
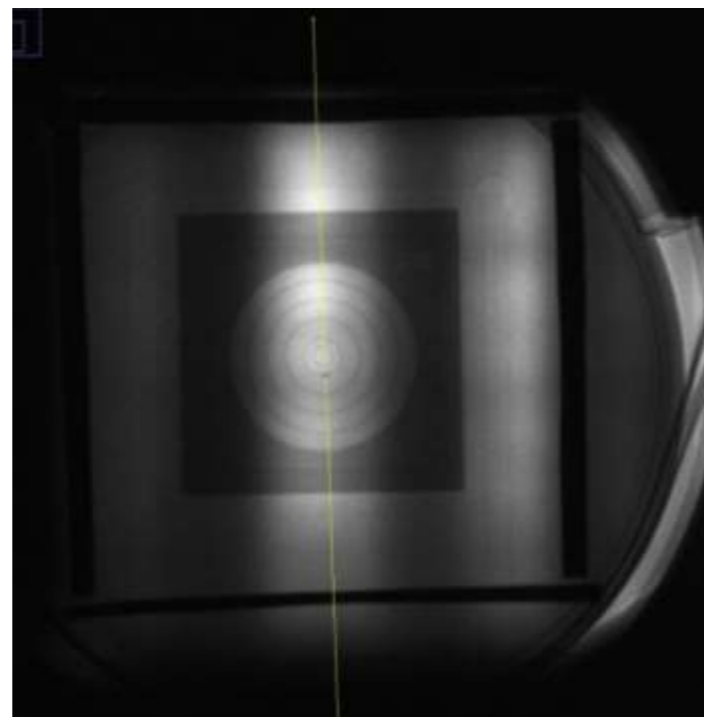
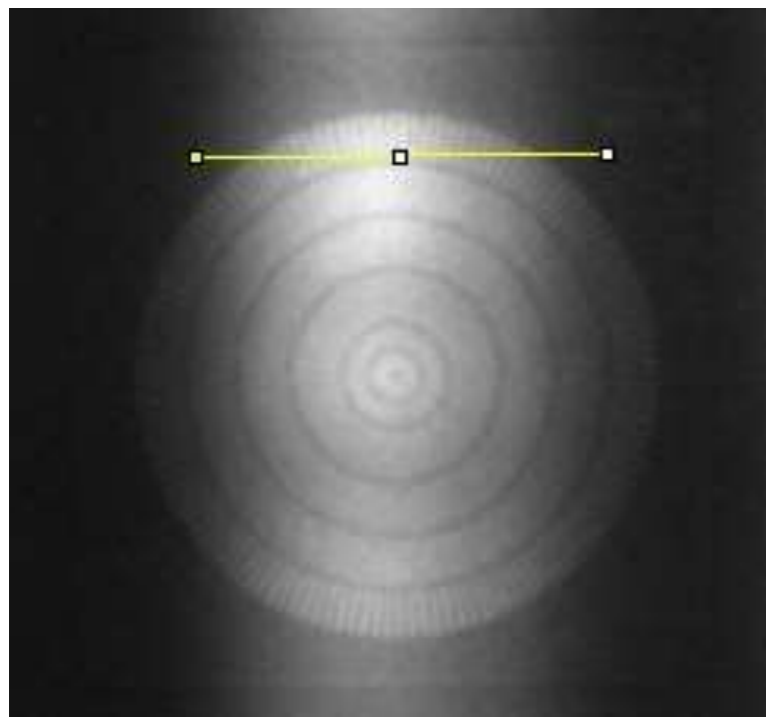
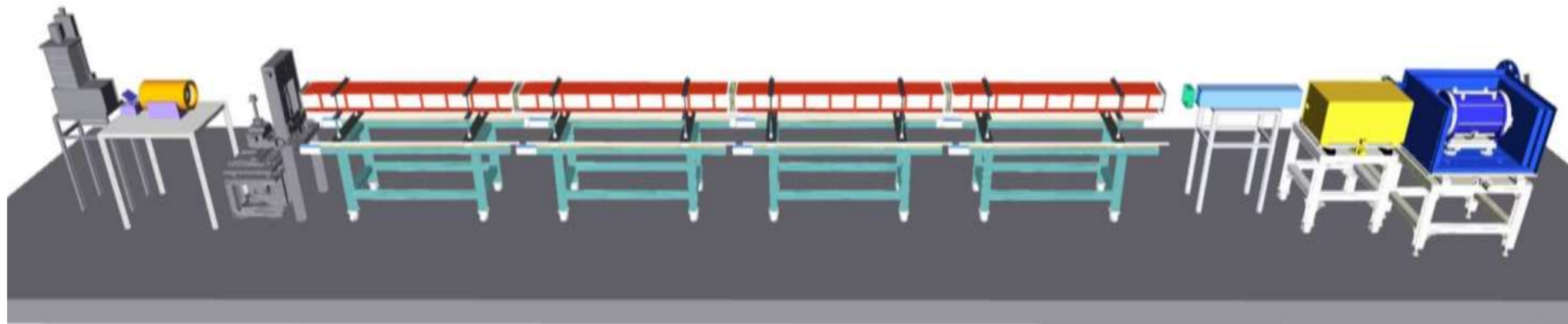
3. Commission on Other Institute

^3He system

**In-situ2 system
adapted to BL-CARR**

ImagR $\sim 420\ \mu\text{m}$

FOV $\geq 6.996\ \text{cm}$



4. Conclusion and Outlook

Conclusion

Filling station, SEOP pumping station and In-situ NSFs established at CSNS.
Design and build the competitive ^3He spin filter systems at CSNS.
Development the neutron spin control systems at CSNS.

Future plan

Upgrade the performance of filling station, pumping station and In-situ NSFs.
Keeping development the neutron spin control systems at CSNS.
Development the wide-angle neutron spin filter system.
Development the MEOP system.
Keeping commissioning the polarized neutron system and technique at CSNS.

Acknowledgment



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CHINA ACADEMY OF ENGINEERING PHYSICS



中国原子能科学院



Thanks for your attention