

# **Polarized $^3\text{He}$ for NOPTREX**

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CSNS

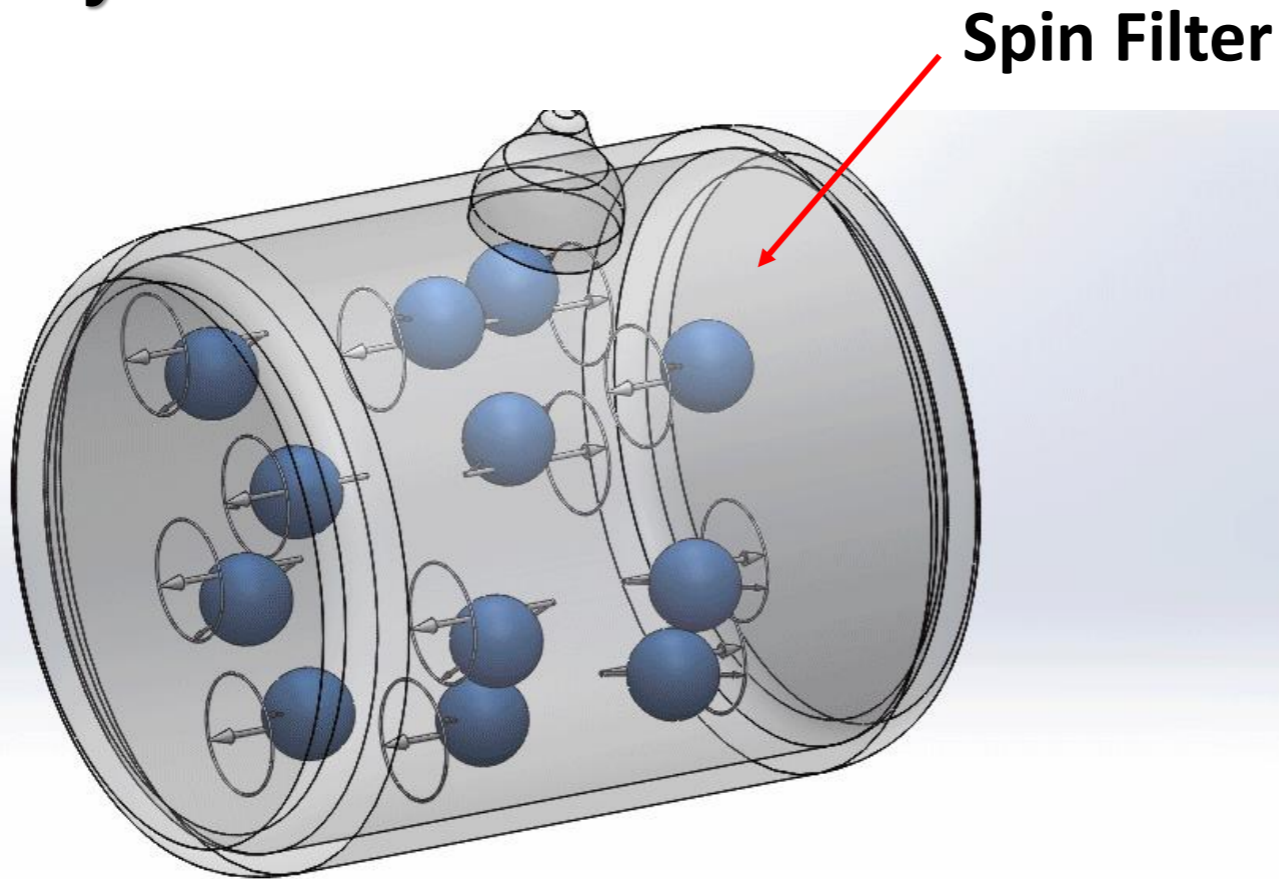
PN Group

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- 2. Development of Polarizing  $^3\text{He}$**
- 3.  $^3\text{He}$  Transmission Experiment at Back-n**
- 4. Conclusion and Outlook**

# 1. Introduction

## Polarize $^3\text{He}$ By SEOP Method



### Including system:

- Air heating
- Rb/K/ $^3\text{He}$  filled filter
- High power pumping laser
- Magnetic field

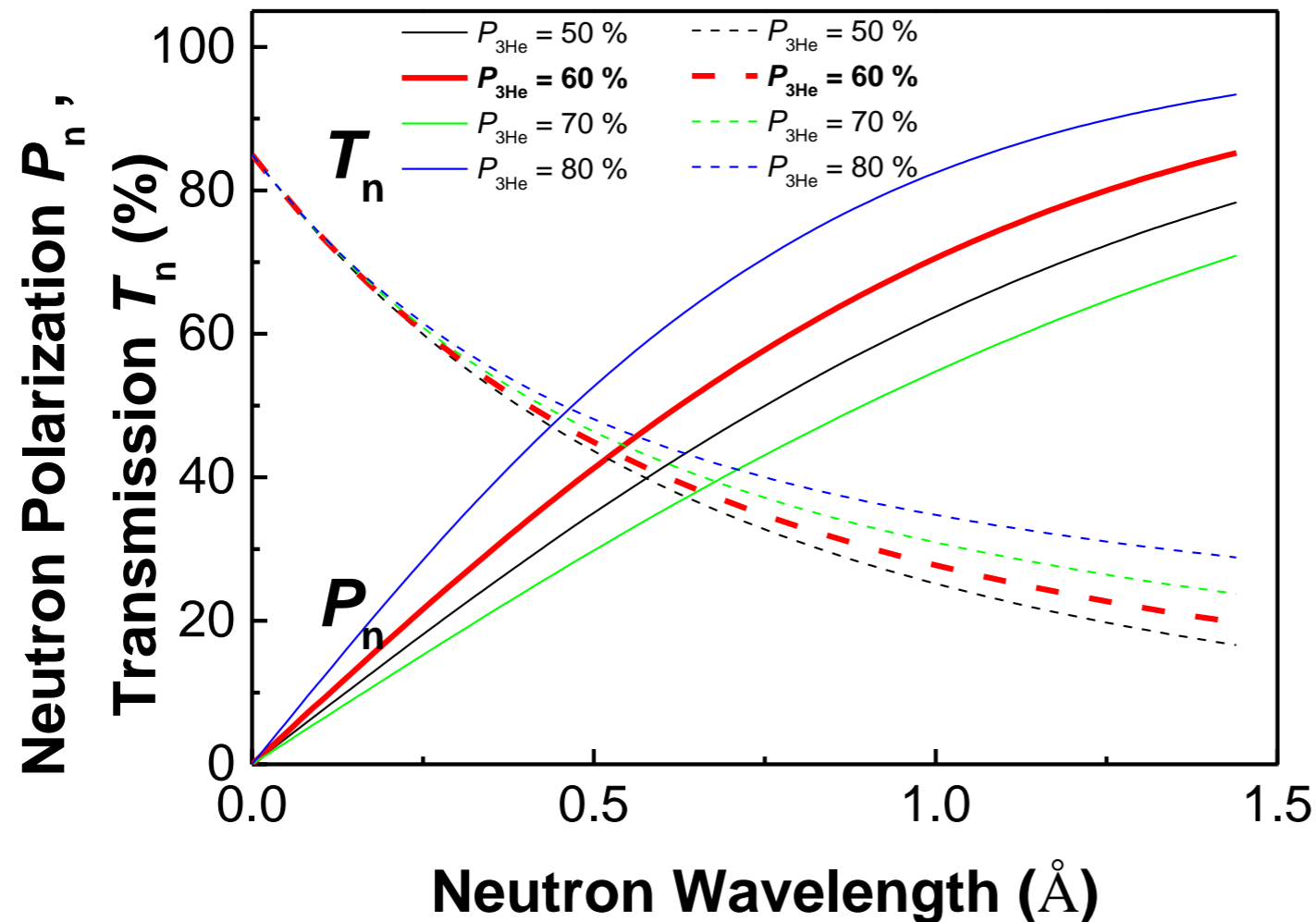
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### Advantages:

- High Pressure  $^3\text{He}$
- Beamline Accessible
- Spin Reversible
- Pre-pumping
- Polarization Stable

# 1. Introduction

## Neutron Polarization VS $^3\text{He}$ Polarization



The relation ship of Neutron polarization and  $^3\text{He}$  polarization

For a certain spin filter:

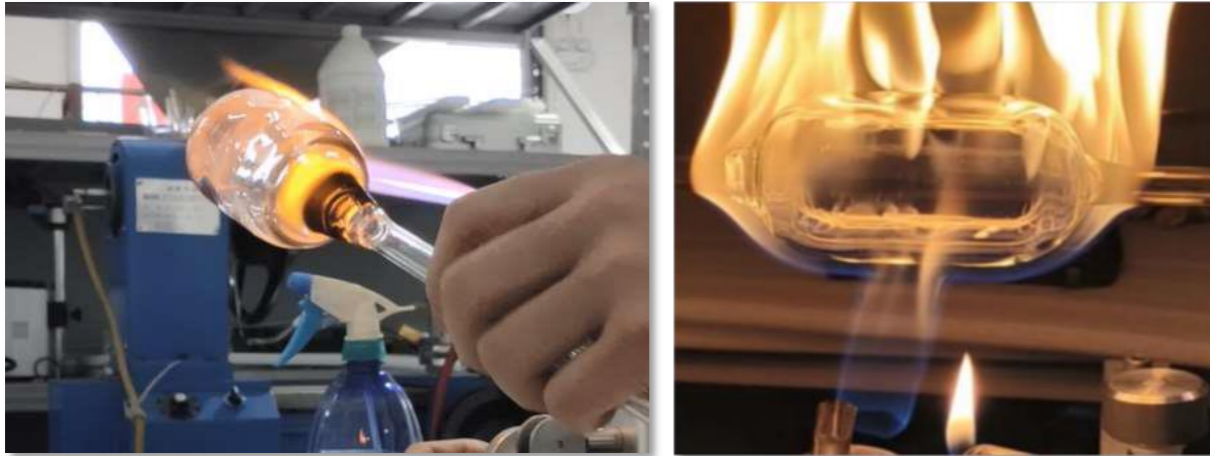
- The higher the  $^3\text{He}$  polarization the higher polarization of neutron
- The higher the  $^3\text{He}$  polarization the weaker transmission of neutron
- The higher the neutron energy the smaller the cross-section to  $^3\text{He}$

Our goal are **higher  $^3\text{He}$  polarization and higher neutron polarization**

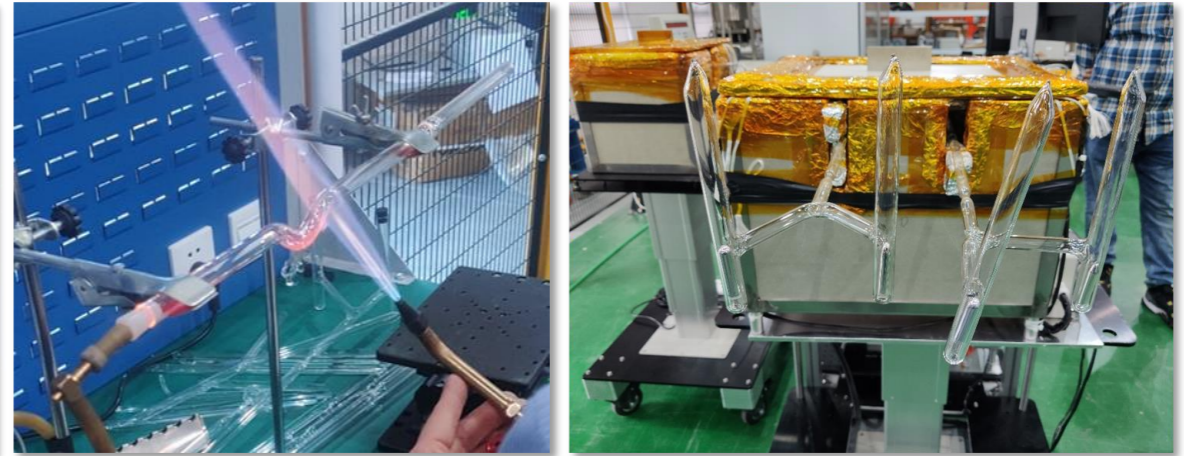
# 2. Development of Polarizing $^3\text{He}$

## SEOP $^3\text{He}$ spin filter development capability

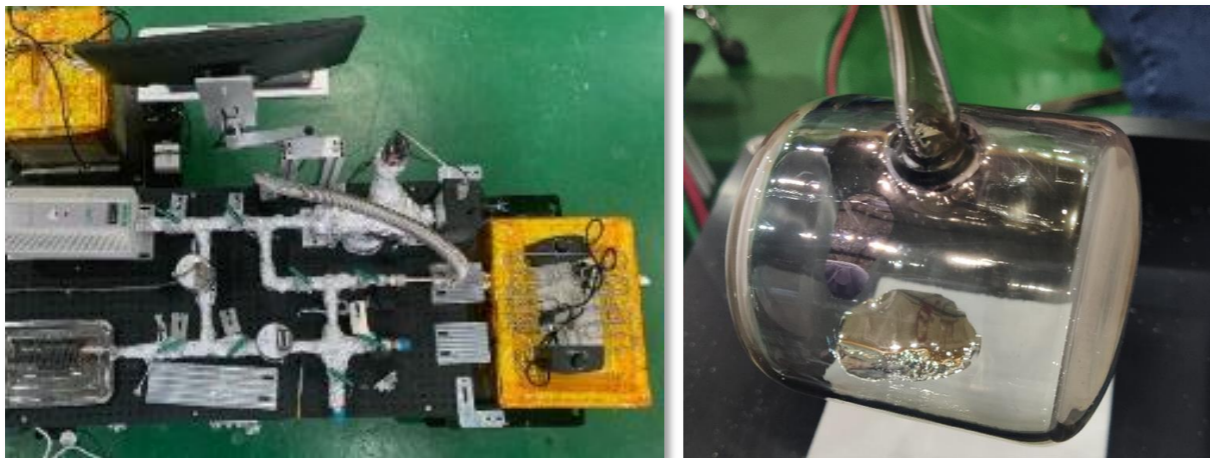
**In-house  $^3\text{He}$  cell fabrication**



**Attach Strings and Clean**



**Heating and Filling**



**Tip off**

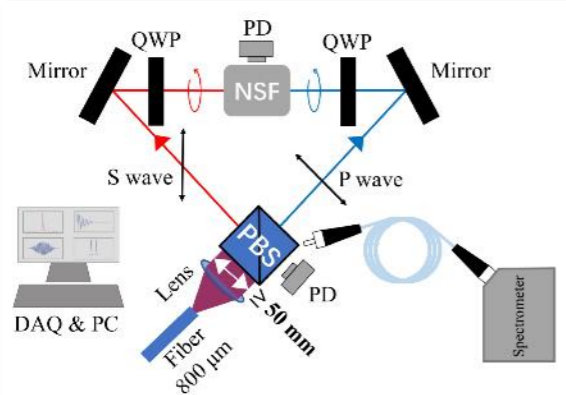
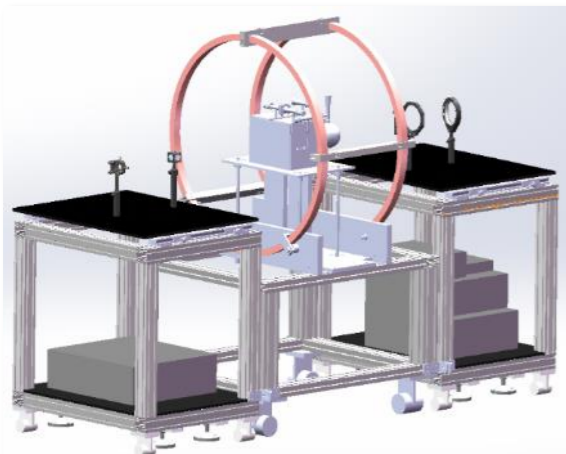


# 2. Development of Polarizing $^3\text{He}$

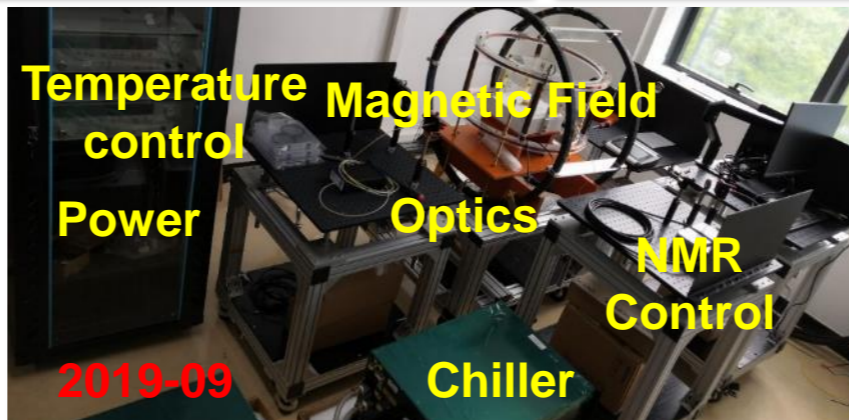
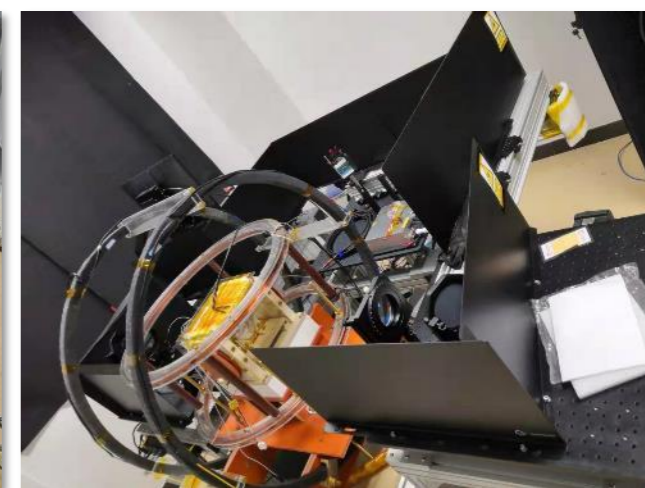
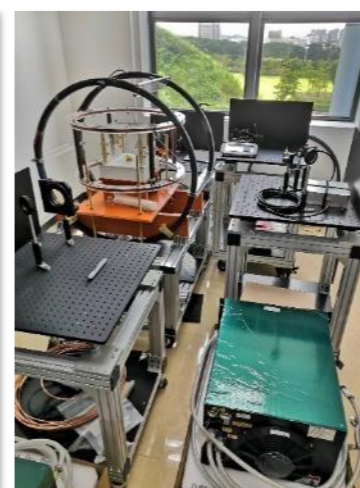
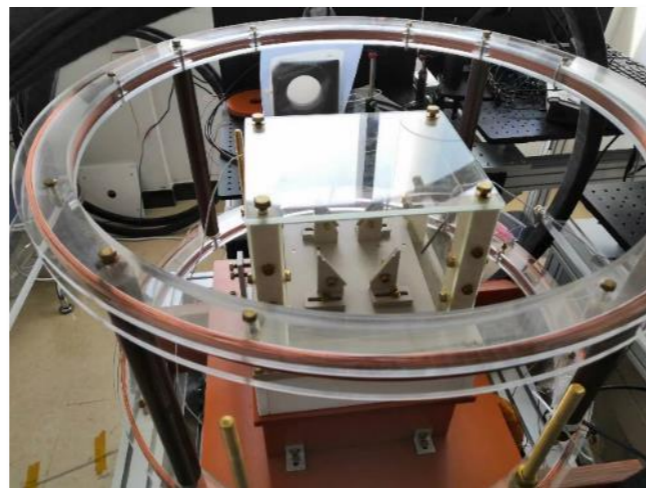
## Off-situ $^3\text{He}$ Pumping Station

Functions:

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



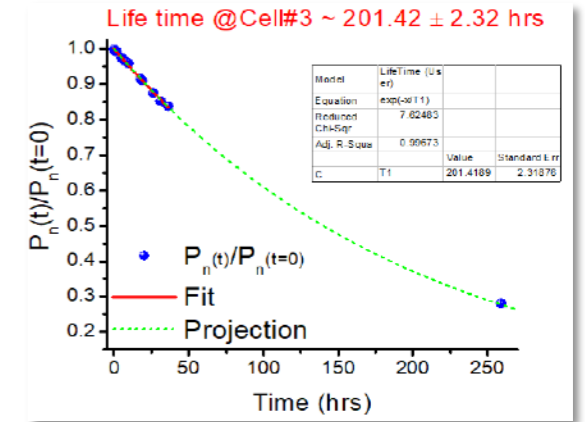
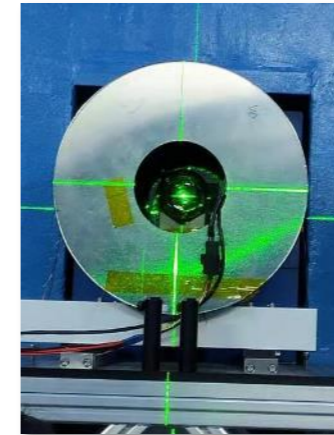
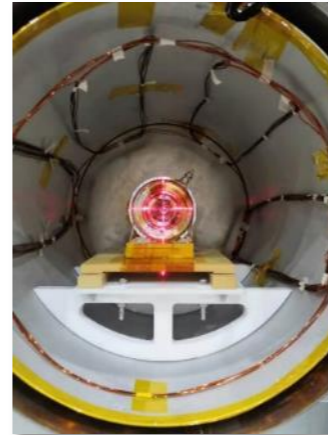
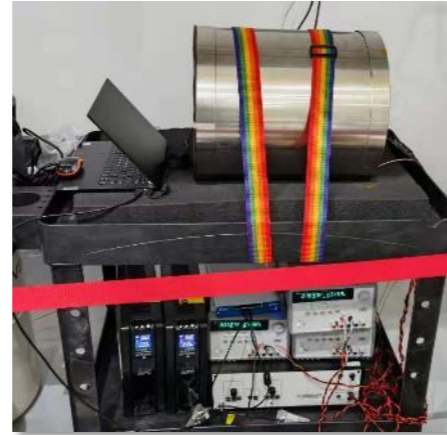
First Generation Design



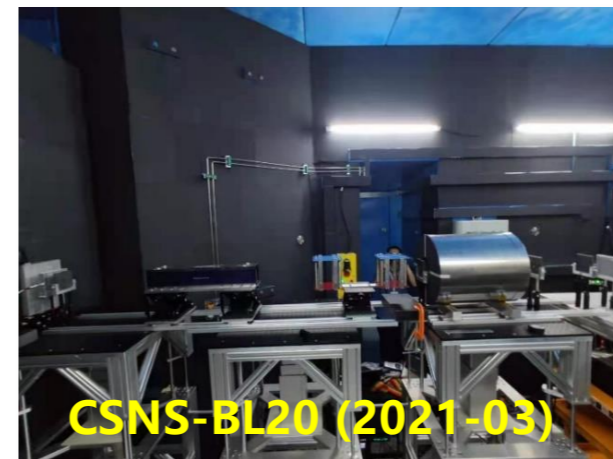
# 2. Development of Polarizing $^3\text{He}$

## Off-situ System

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

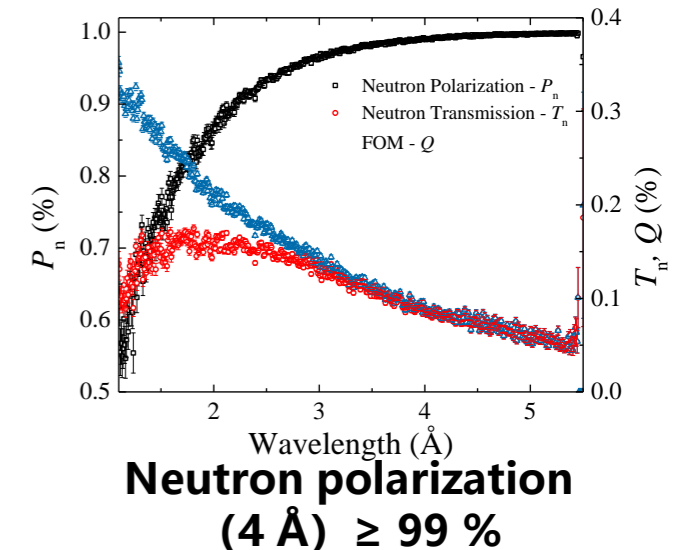


**Install in the Beamline**



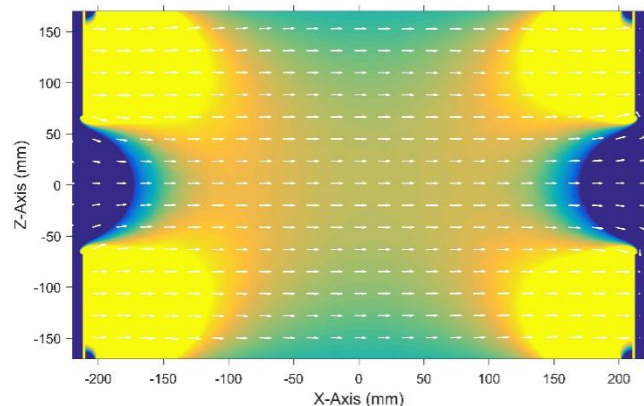
**Examined By Neutron**

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

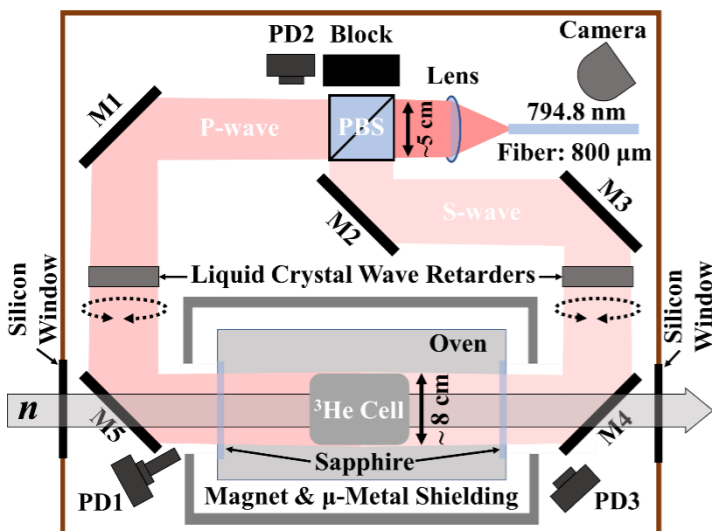


# 2. Development of Polarizing $^3\text{He}$

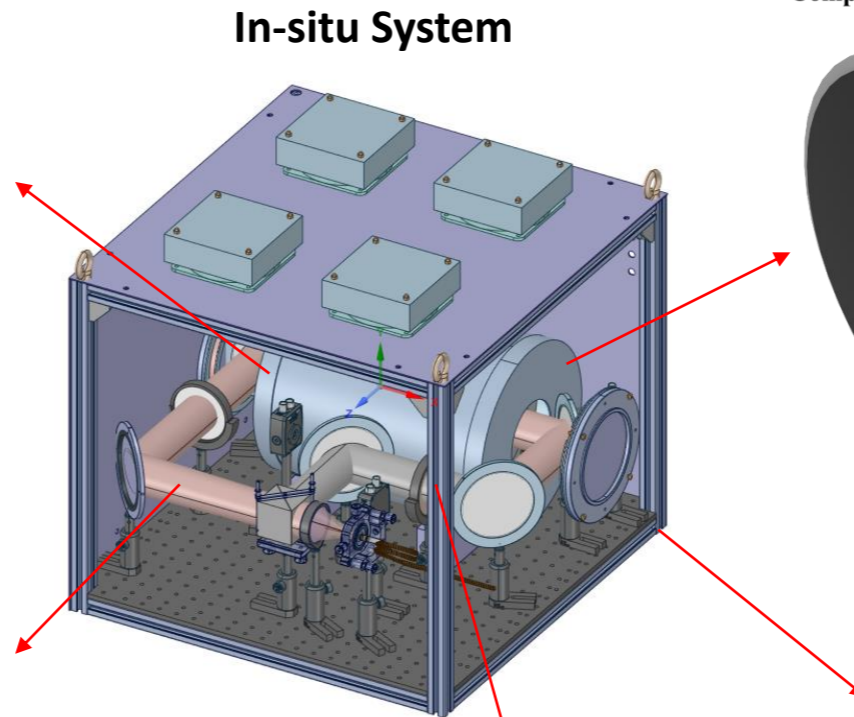
## In-situ System: Pumping system and spin filter



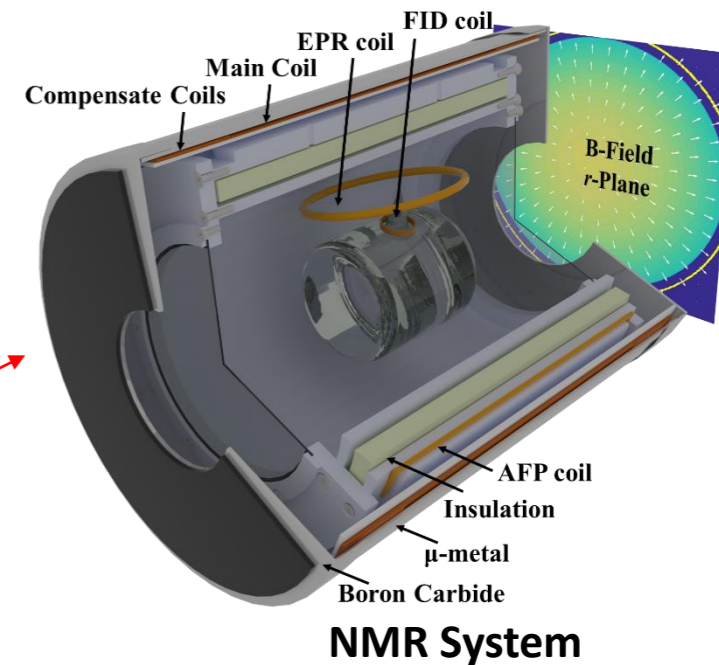
Magnetic field



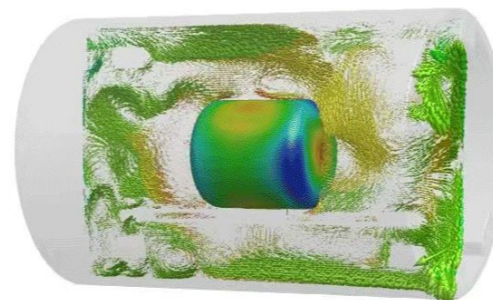
Optical Setup



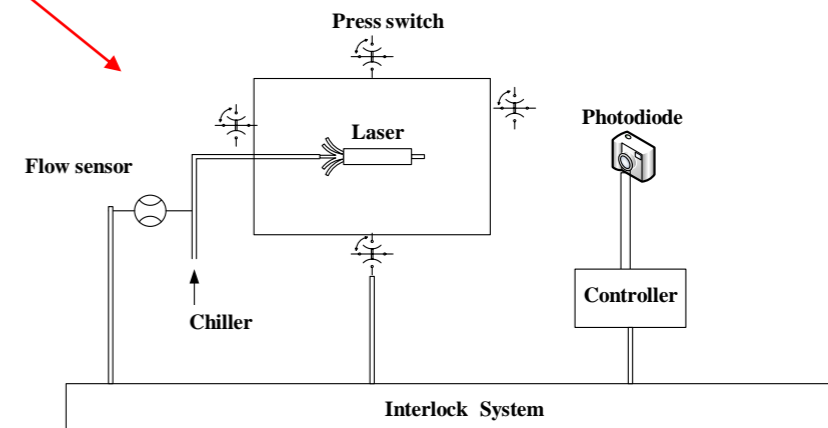
In-situ System



NMR System



Heating Simulation



Safety Interlock



# 2. Development of Polarizing $^3\text{He}$

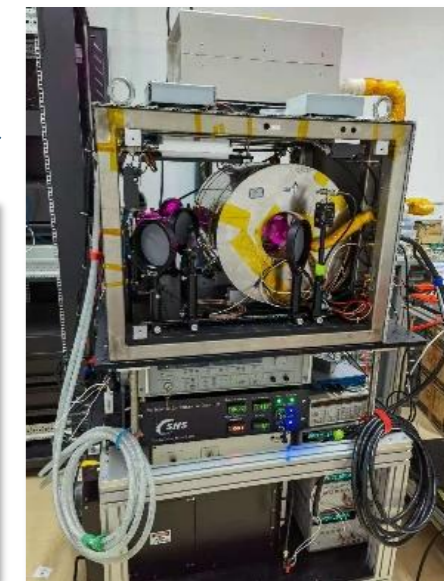
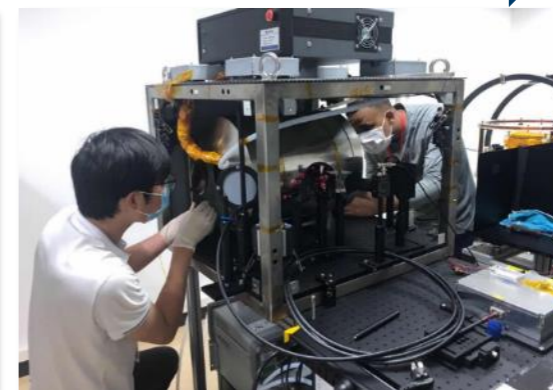
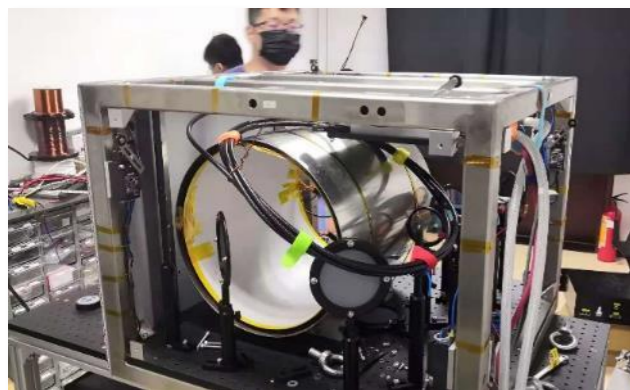
**In-situ system** Integrated the system together and measured online  
Pumping station Magnetic field Spin filter ...

Off-line running

Frame

Install  $^3\text{He}$

Optics + Heating Oven



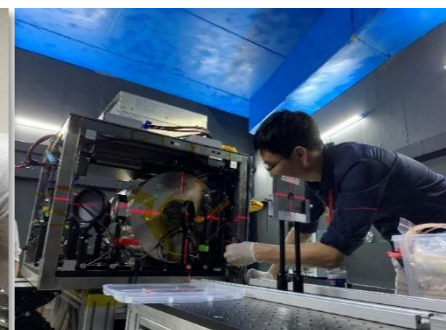
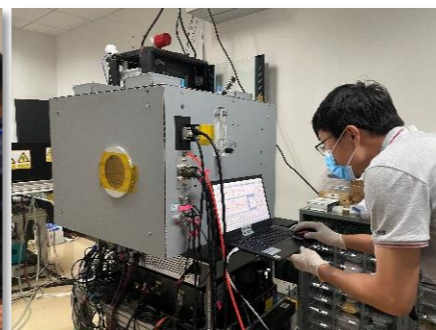
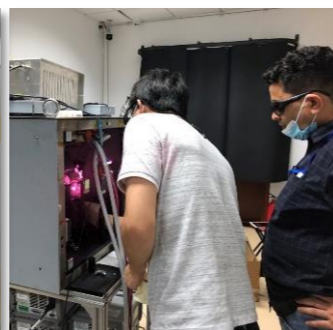
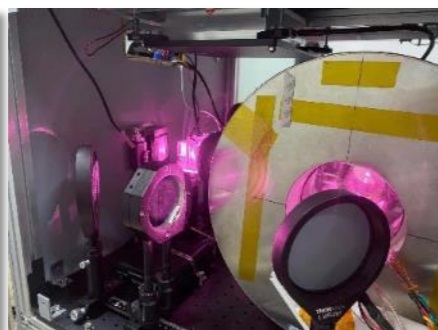
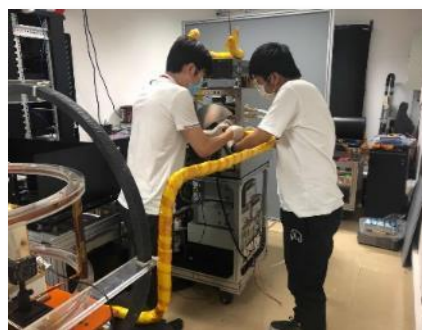
Heating testing

upgrade

Pre-running

Aliment on beamline

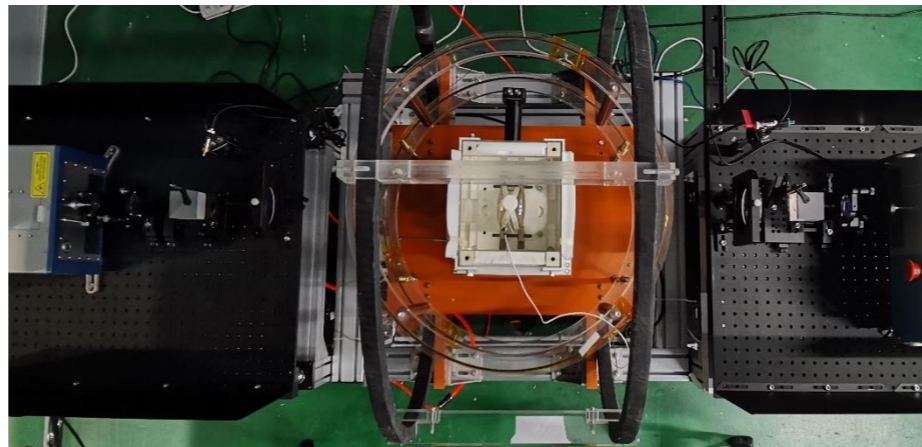
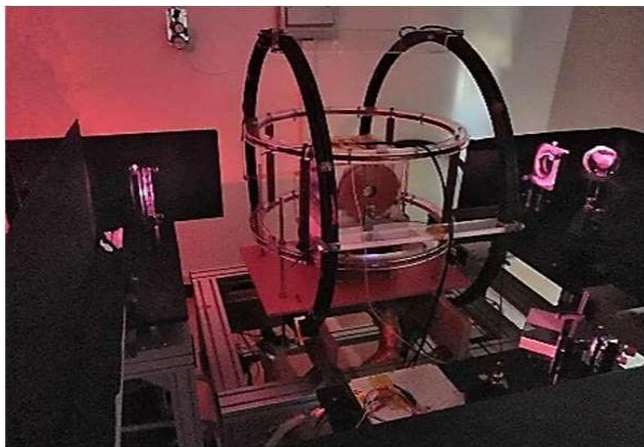
Continuous running



# 2. Development of Polarizing $^3\text{He}$

## $^3\text{He}$ System

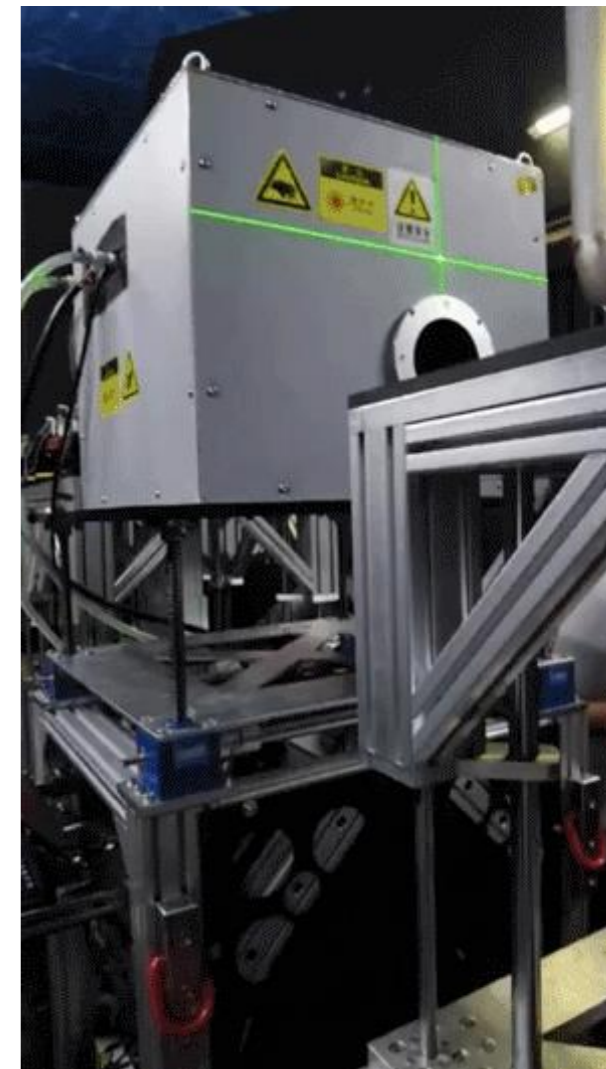
2 off-situ station + 2.5 In-situ system



Pumping station: Cell selection & off-situ

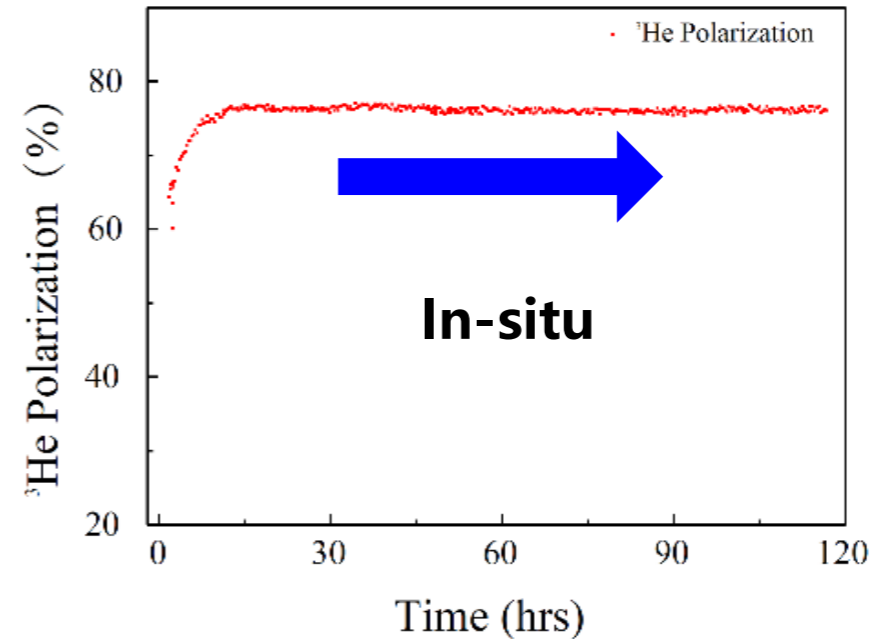
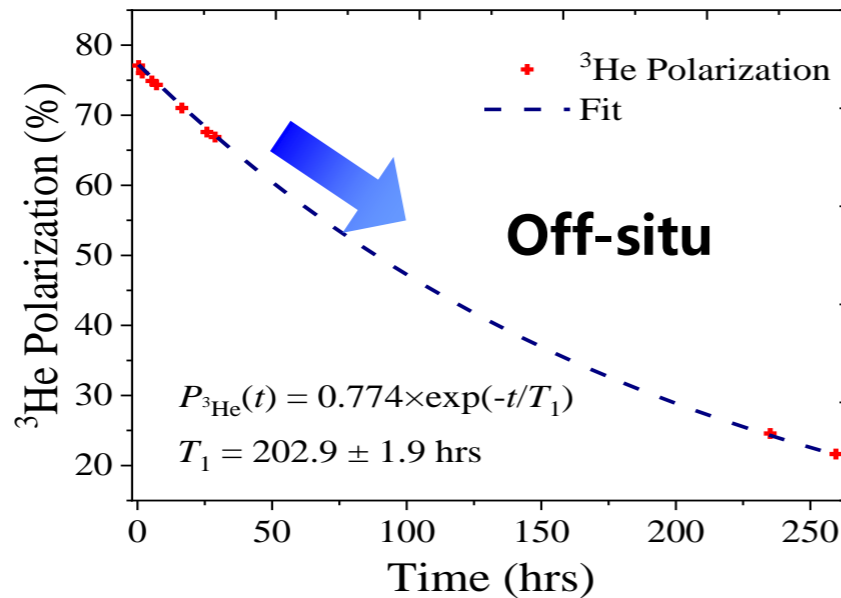


In-situ system



# 2. Development of Polarizing $^3\text{He}$

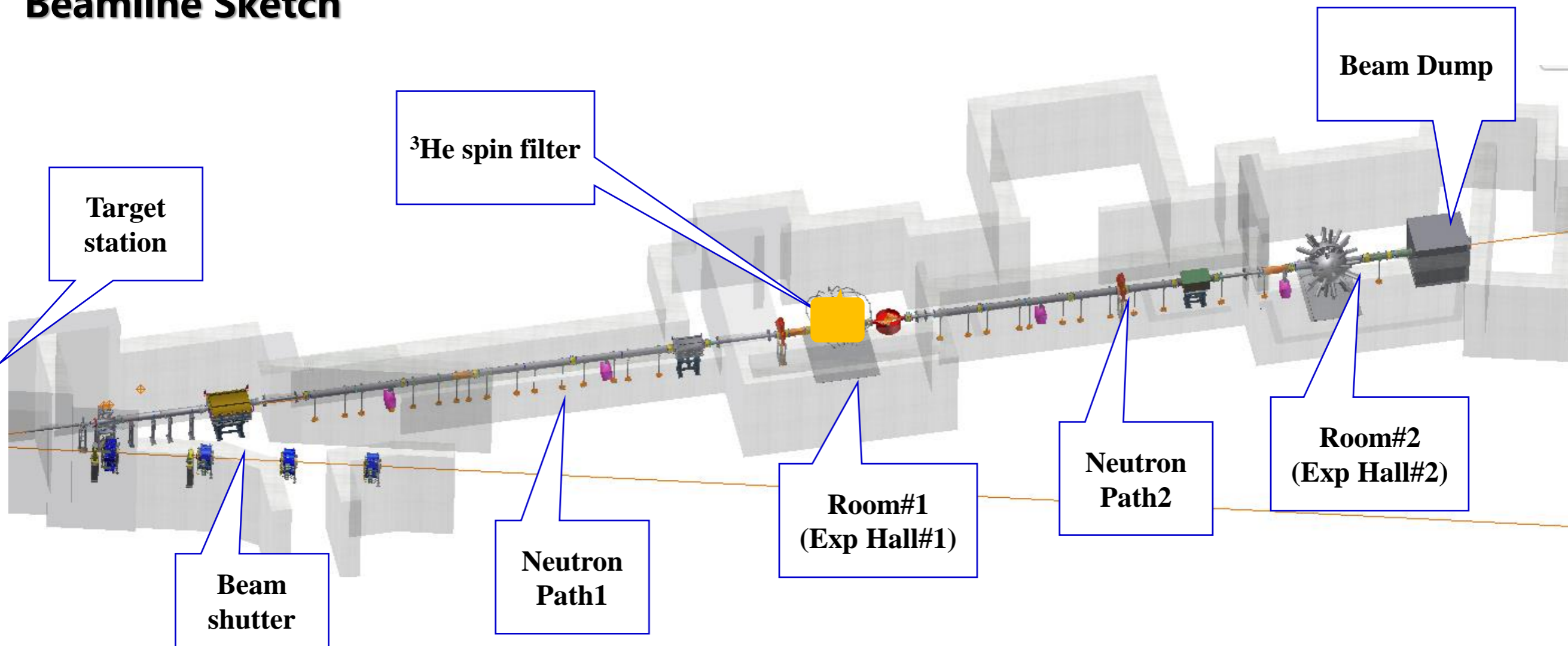
## Parameters of $^3\text{He}$ Spin Filter System



System Type	System Length	Cell Length	Cell Pressure	$^3\text{He}$ 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%

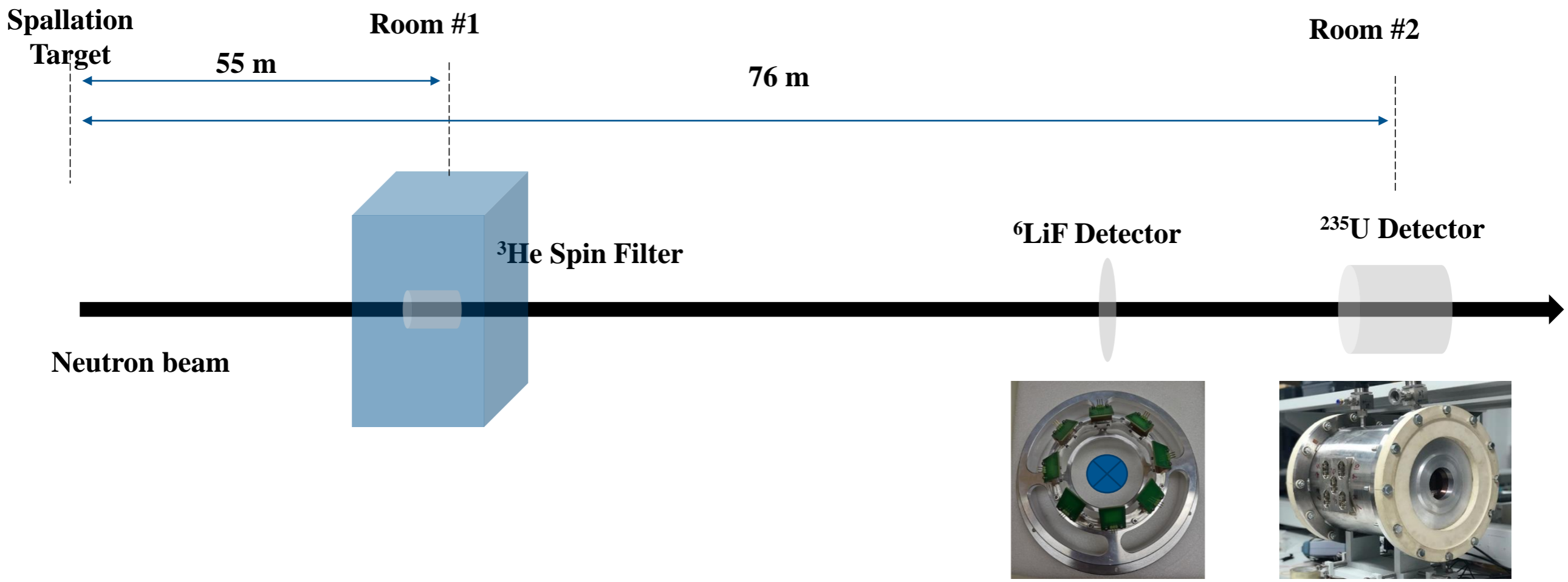
# 3. $^3\text{He}$ Transmission Experiment at BN

## Beamline Sketch



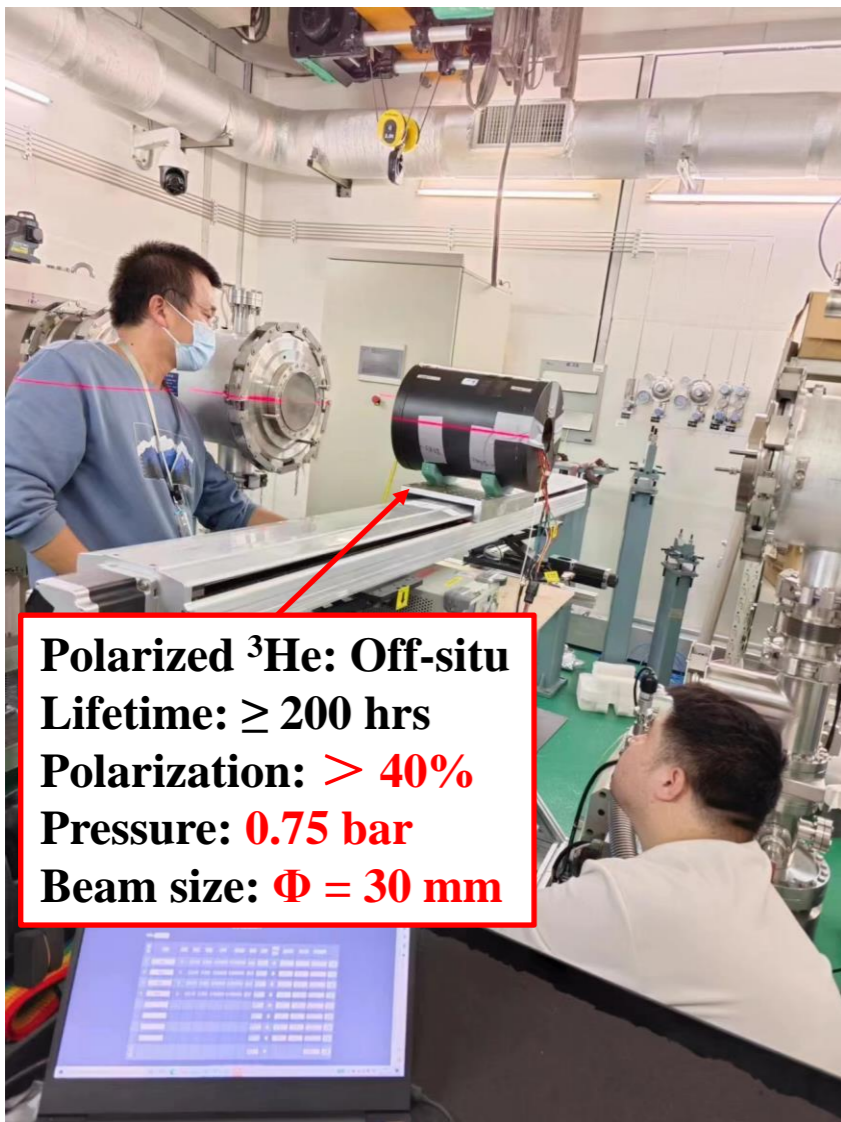
# 3. $^3\text{He}$ Transmission Experiment at BN 中國散裂中子源 China Spallation Neutron Source

## Experiment Setup



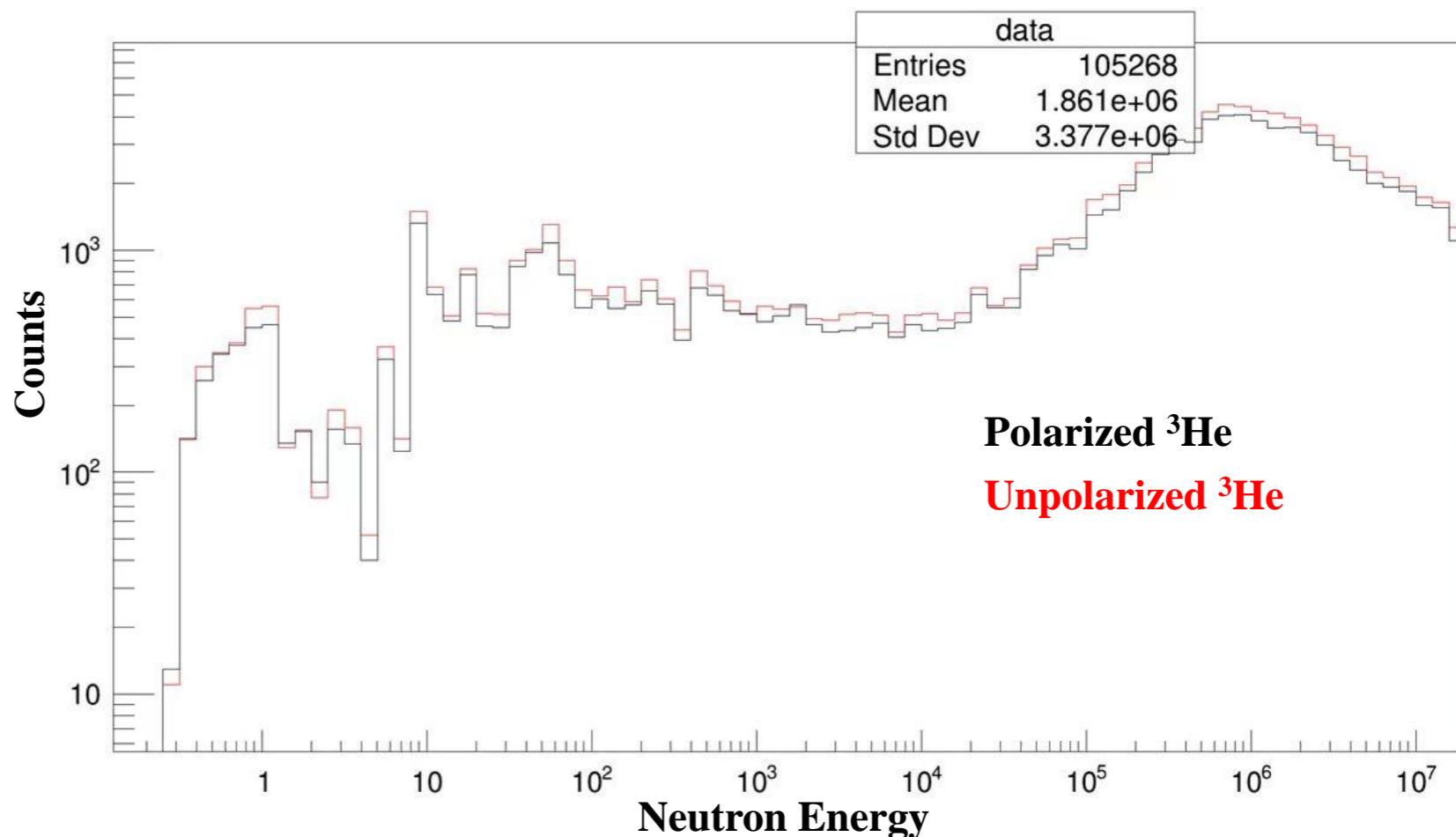
# 3. $^3\text{He}$ Transmission Experiment at SNS 中國散裂中子源 China Spallation Neutron Source

## Pre-Experiment: off-situ



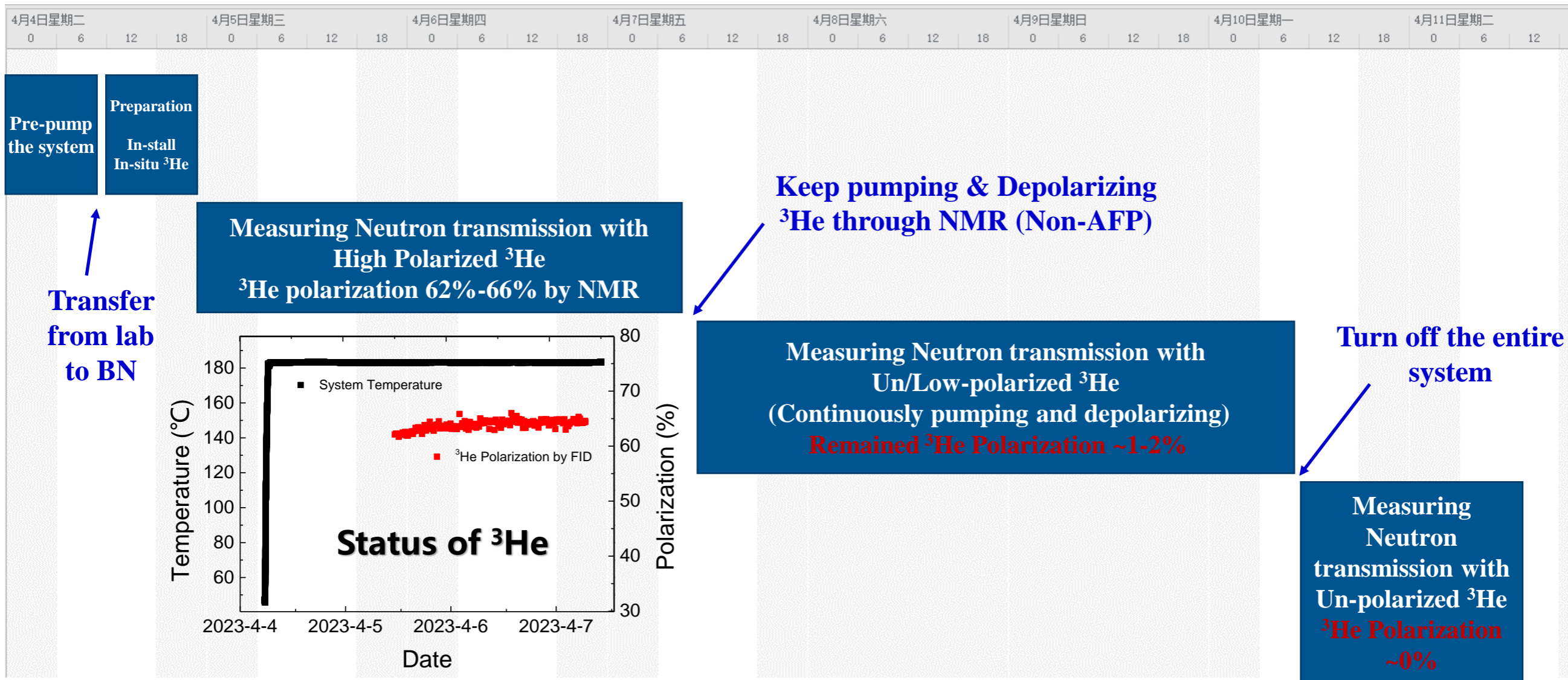
**Polarized  $^3\text{He}$ : Off-situ**  
**Lifetime:  $\geq 200$  hrs**  
**Polarization:  $> 40\%$**   
**Pressure:  $0.75$  bar**  
**Beam size:  $\Phi = 30$  mm**

The difference between polarized  $^3\text{He}$  and unpolarized  $^3\text{He}$  is **Detectable**  
**But SNR was poor !  $\rightarrow$  Need higher pressure and polarization of  $^3\text{He}$**   
**Also need higher flux of neutron beam**



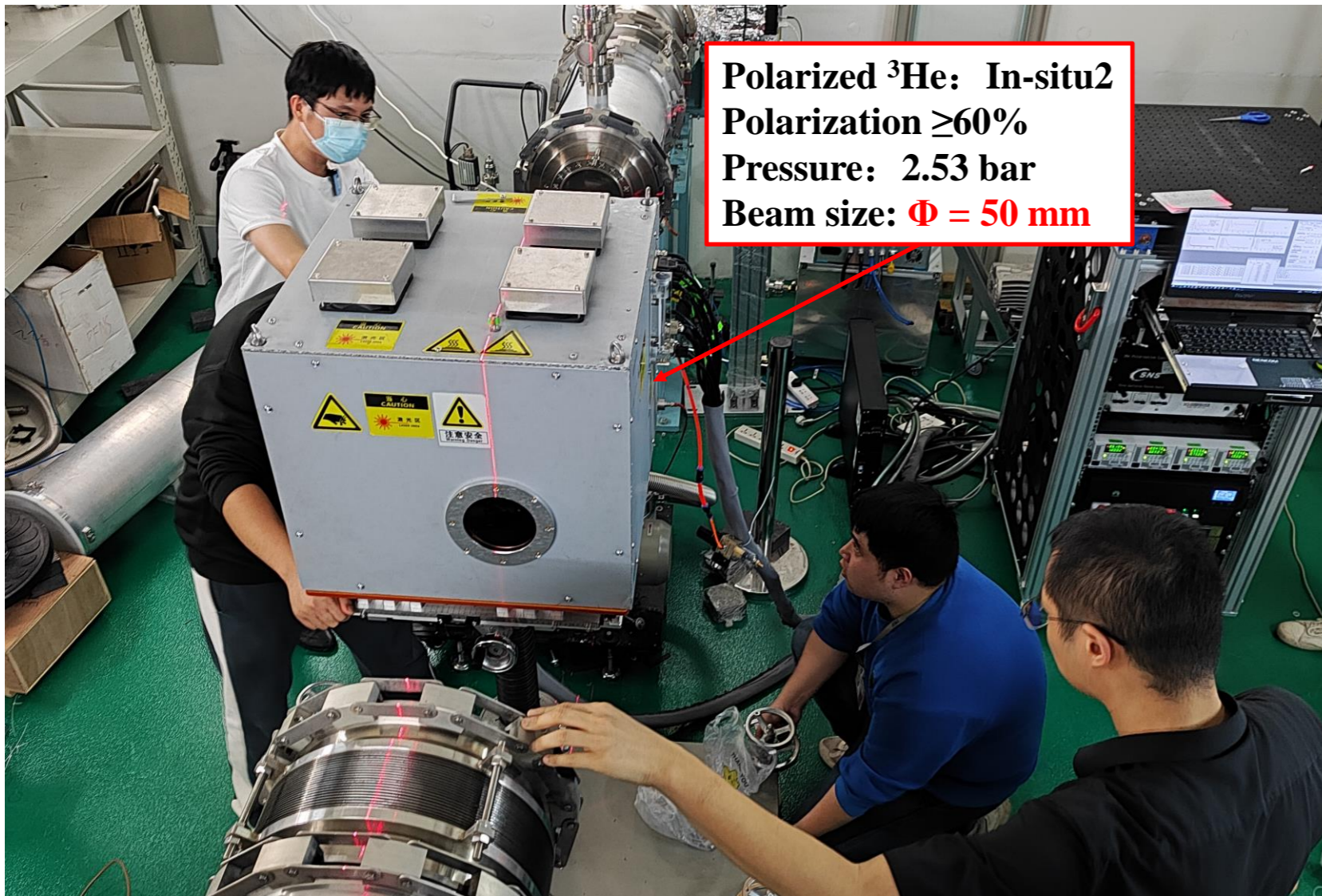
# 3. $^3\text{He}$ Transmission Experiment at BN 中國散裂中子源 China Spallation Neutron Source

## Upgrade Experiment Schedule: In-situ



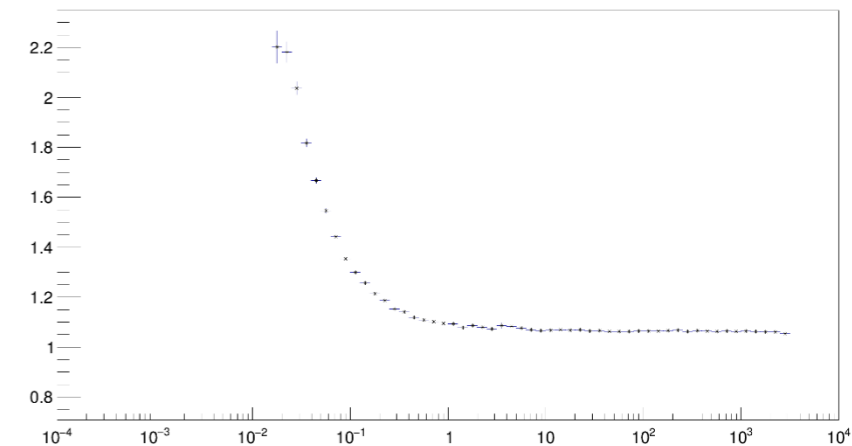
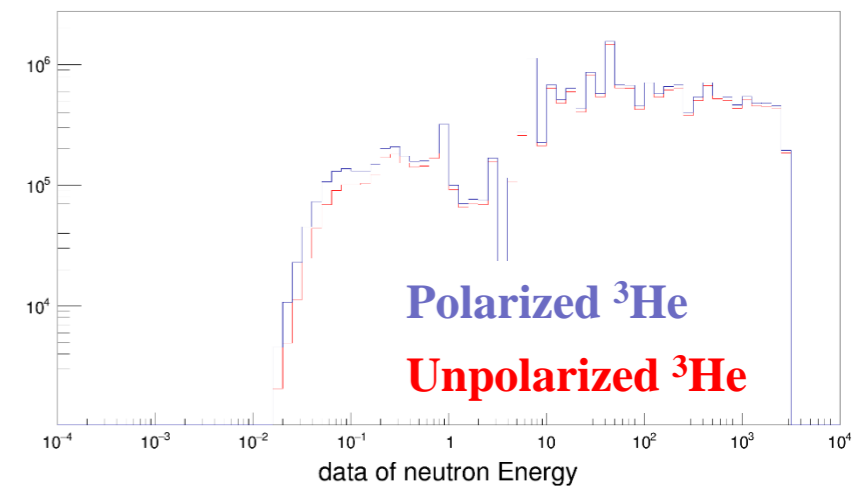
# 3. $^3\text{He}$ Transmission Experiment at SNS 中國散裂中子源

## Upgrade Experiment: In-situ



### Transmission of polarized/unpolarized $^3\text{He}$

data of neutron Energy



### Transmission of polarized $^3\text{He}$ divide with unpolarized $^3\text{He}$

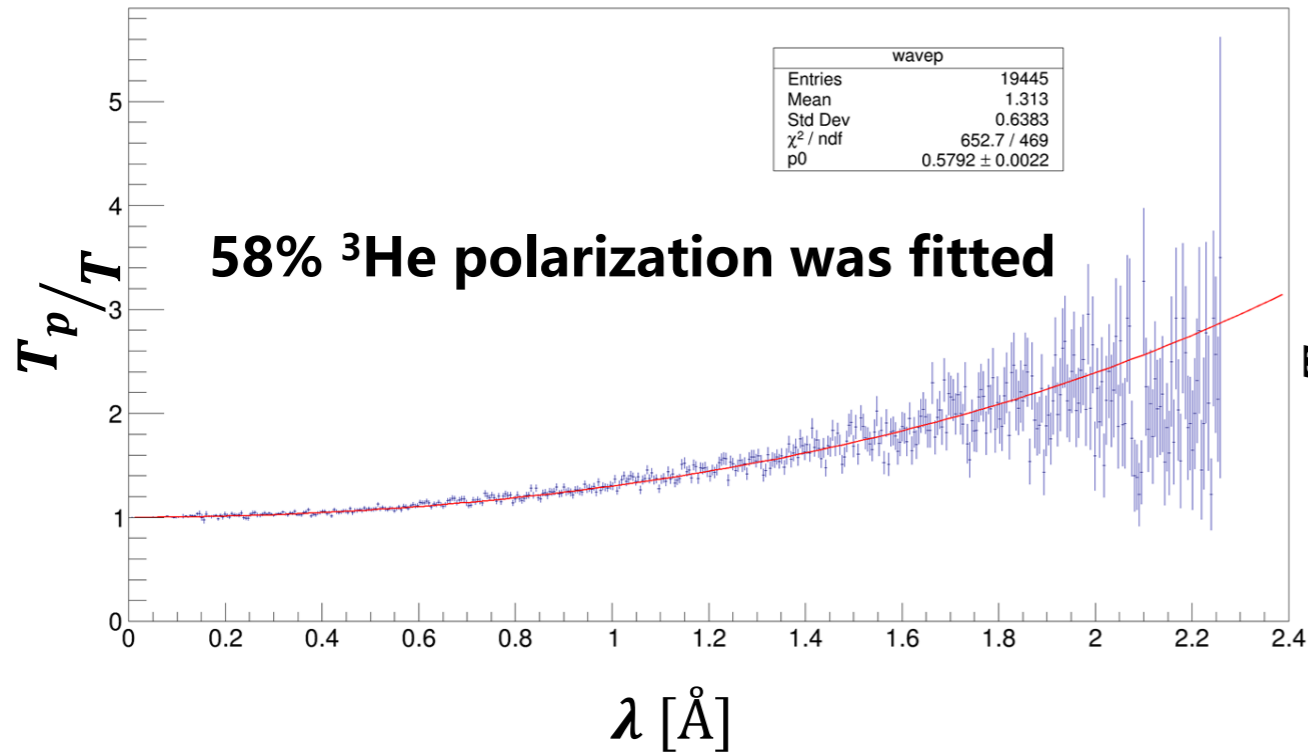


# 3. $^3\text{He}$ Transmission Experiment at BN

## Ratio of Polarized vs Unpolarized data

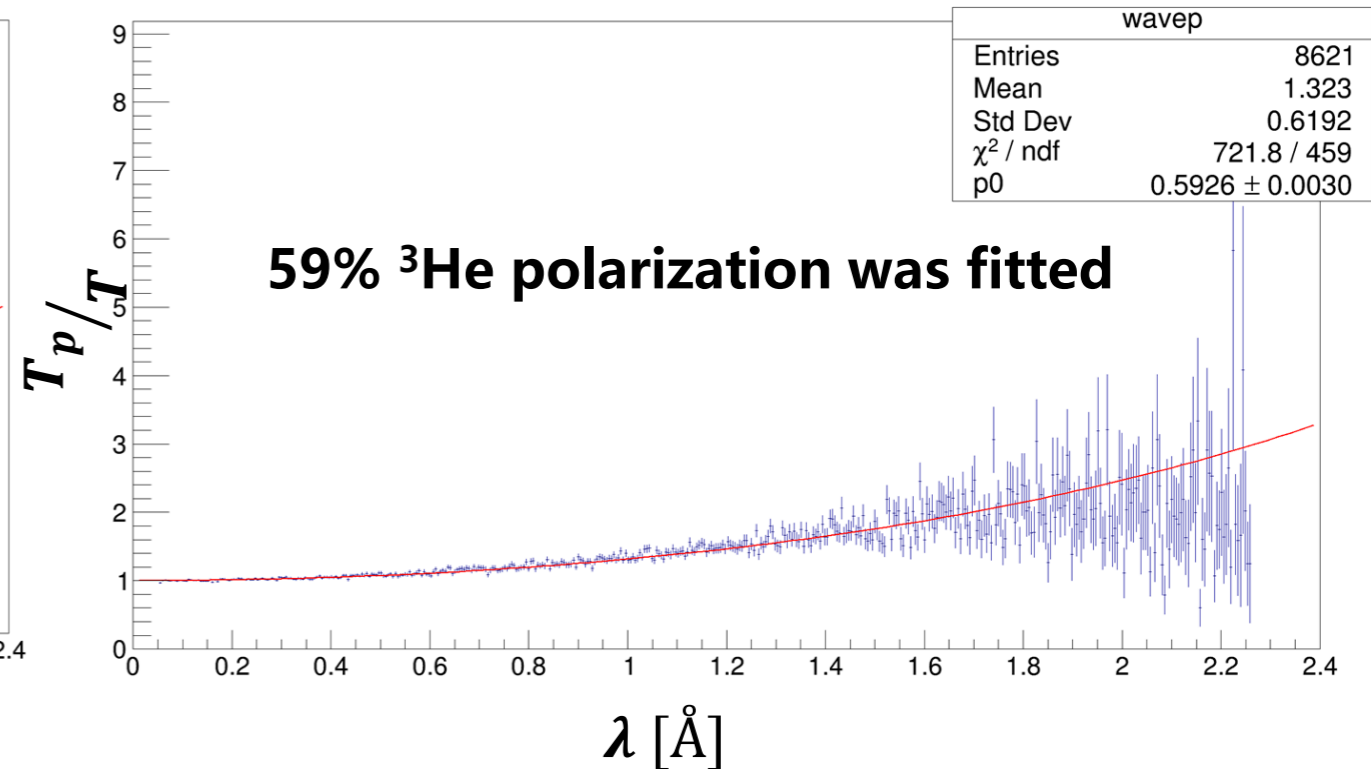
### Data From $^{235}\text{U}$

wavelength of polarized  $^3\text{He}$



### Data From $^6\text{Li}$

wavelength of polarized  $^3\text{He}$



# 4. Conclusion and Outlook

## Problems

1. The polarization of  $^3\text{He}$  measured at BN is much lower than other beamline
2. The baseline of the proton is not very reliable
3. The depolarizing operation is not continuously
4. The data acquisition rate and statistic is not very high
5. The scattering length of neutron with  $^3\text{He}$  is inadequate

## Conclusion

1. The off-situ system proved that the transmission difference for  $^3\text{He}$  is detectable
2. The In-situ system give a better SNR, but at high energy range, the difference still small
3. Higher pressure and longer length of  $^3\text{He}$  cell is better
4. Continuously depolarizing operation should be applied

## Future plan

1. Insert monitor to the beam
2. Replace the detector with even higher efficiency
3. Combine two In-situ system to increase the transmission length
4. R&D new in-situ system

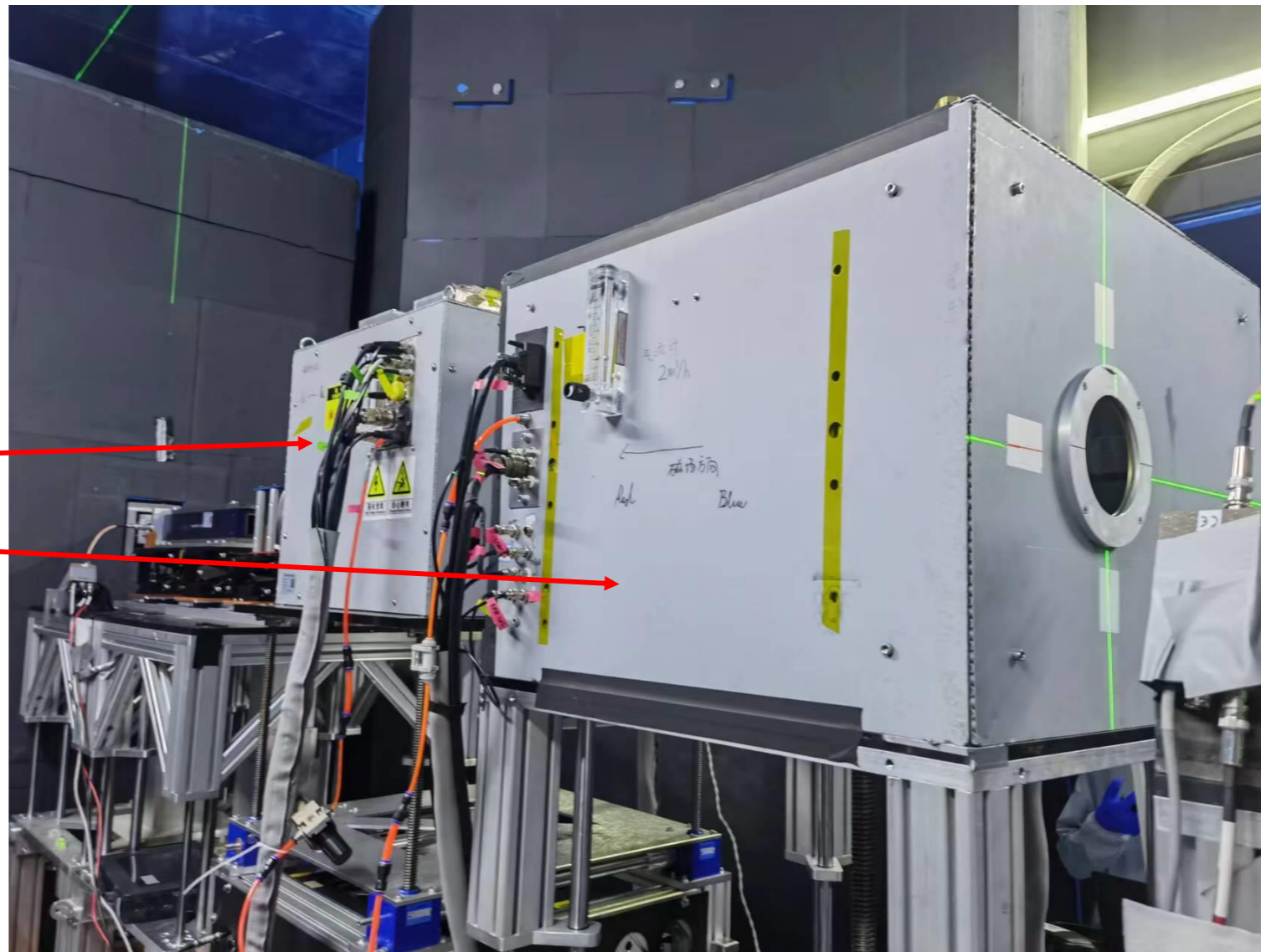
# 4. Outlook

## $^3\text{He}$ system

Two system were combined together and under measurement at BL20-CSNS

In-situ2

In-situ1



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

**Thank You!**