NRS/IXS： BL再編とアップグレード
施設での検討状況・計画
NRS/IXS: BLs Restructuring and Upgrade
Present status and plan at SPring-8 facility

Yoshitaka Yoda

Hiroshi Uchiyama

JASRI / SPring-8

第2回 SPRUC BLsアップグレード検討ワークショップ

@ SPring-8

February 22, 2020

NRS (Nuclear resonant scattering) upgrade

NRS activities at BL09XU
To BL35XU

Yoshitaka Yoda

JASRI / SPring-8

第2回 SPRUC BLsアップグレード検討ワークショップ
@ SPring-8
February 22, 2020

NRS利用高度化WG
WG for the promotion of NRS research

Coordinator: Y. Yoda

Member: Dr. MItsui（BL11XU）, Dr. Tamasaku（BL19LXU）, Dr. Uchiyama（BL35XU）, Prof Seto（user）

Observer: Dr. Yabashi, Dr. Sakurai, Dr. Kimura, Dr. Ohashi, Dr. Baron

Start in July

WG meeting

1st	9/3	Present status of the NRS activities
		Advantage and possible problems at BL35XU
	9/13	SPRUC NRS meeting
2nd	10/1	Future plan of NRS research
3rd	11/5	Research fields, spectroscopic methods and instruments
4th	12/19	NRS at BL35XU
		Layout at optics hutch and NRS experimental hutches
5th	1/23	Brushing up in detail, Schedule, Efficient operation

Techniques at BL09XU

・ Energy domain Mössbauer Spectroscopy

Seto et. al., PRL 1 (2009) 217602

・ Time domain Mössbauer Spectroscopy

・ Nuclear Inelastic scattering
(Nuclear Resonance Vibrational Spectroscopy)

Seto et. al., PRL 74 (1995) 3828

・ Quasi-elastic scattering
using gamma-ray time-domain interferometry

Baron et. al., PRL 79 (1997) 2823

Saito et. al., PRL 109 (2012) 115705

・ Nuclear excitation

Kishimoto et. al., PRL 85 (2000) 1831
Masuda et. al., Nature 573 (2019) 238

____ Japan, SPring-8, SPrng-8 staff original techniques

Spectroscopies and techniques using NRS

Techniques	Energy width	Information you can get	Target
Synchrotron Mössbauer Spectroscopy (Energy / Time domain)	~ neV	Electronic states	Spintronics, Electrode, Quantum critical phenomena, Earth science etc.
Nuclear Inelastic scattering (NRVS)	~ meV	Vibrational states	Enzyme, Catalyst, Thermoelectric material, Glass, Solid state physics, Earth science etc.
Quasi-elastic scattering using gamma-ray time-domain interferometry	neV ~ μeV	Dynamics	Ion liquid, Ion conducting glass, Rubber, Liquid crystal, Membrane protein
Nuclear excitation	~ feV	Nucleus	Nuclear clock

		Synchrotron Mössbauer Spectroscopy	Nuclear Inelastic scattering (NRVS)	Quasi-elastic scattering using gamma-ray time-domain interferometry	Nuclear excitation etc.
Information you can get		Electronic states (Valance・magnetic order・Coordination etc.)	Vibrational states (Partial PDOS・Sound velocity・Coordination etc,)	Dynamics (Q: 1 ~ 100 nm^{-1} ω: nsec – sub-μsec)	
Fundamental Science	Fundamental Physics				◎
	Quantum critical phenomena (SC)	◎	○		
	Glass transition		○	◎	
Material Science	Spintronics	◎			
	Magnet, Steel	◎			
	Electrode	◎	○		
	Thin film device	◎	○		
	Catalyst		◎		
	Thermoelectric material		◎		
	Ion liquid, Ion conducting glass			◎	
	Rubber, Liquid crystal			◎	
Earth science		◎	◎		
Life science (Biochemistry)	Enzyme	◎	◎		
	Heme protein		◎		
	Membrane protein			○	

Overview of NRS experiments

Current status

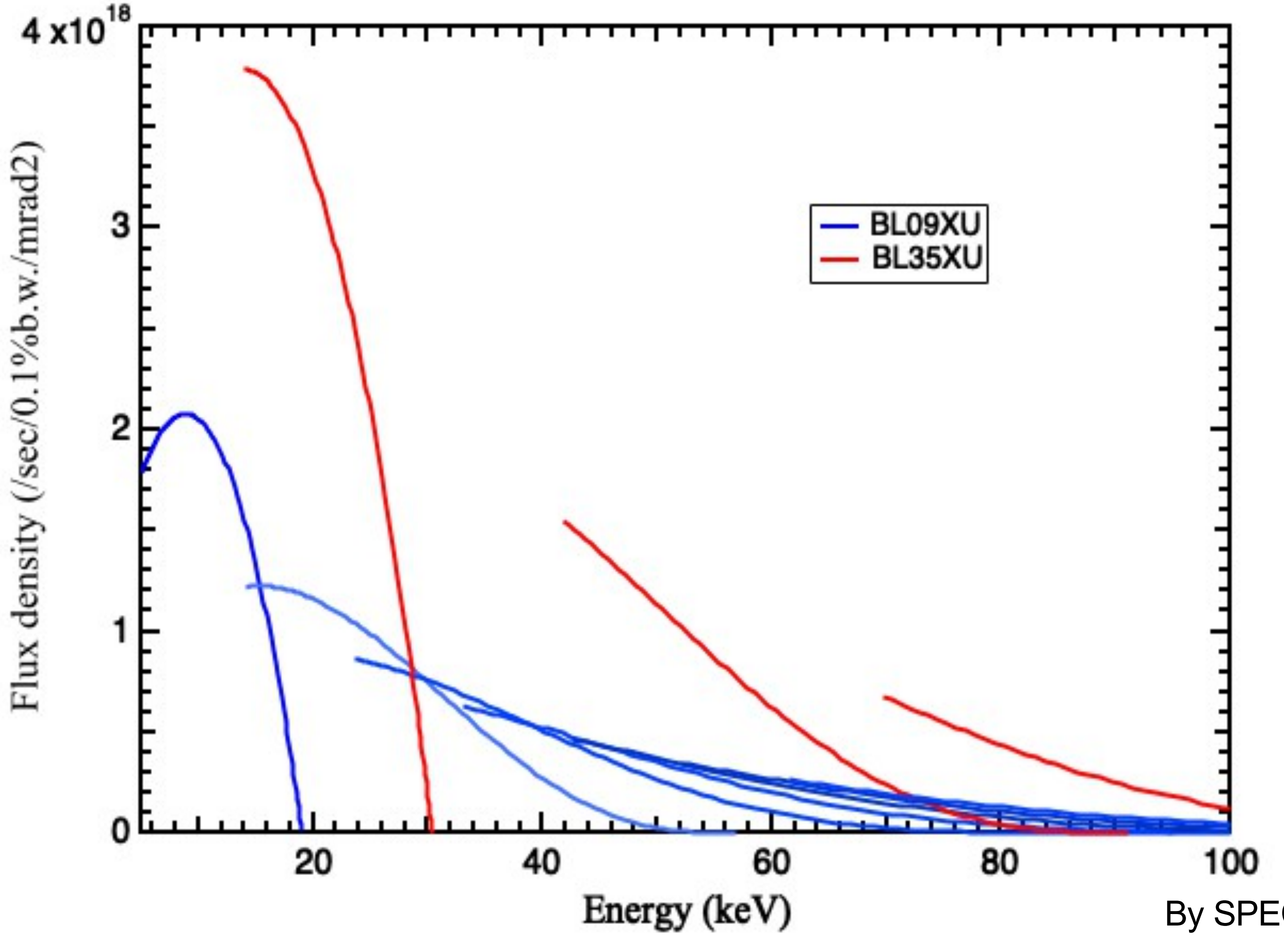
- **Intensity hungry**
  - 5 ~ 6 days / proposal
  - use of RIKEN long-undulator BL (BL19LXU)
    - 20% open for public
    - RIKEN visiting scientist

Toward SPring-8 II (users society)

Nano beam	△
Coherence	△
Polarization	○

Intensity is one of the barriers

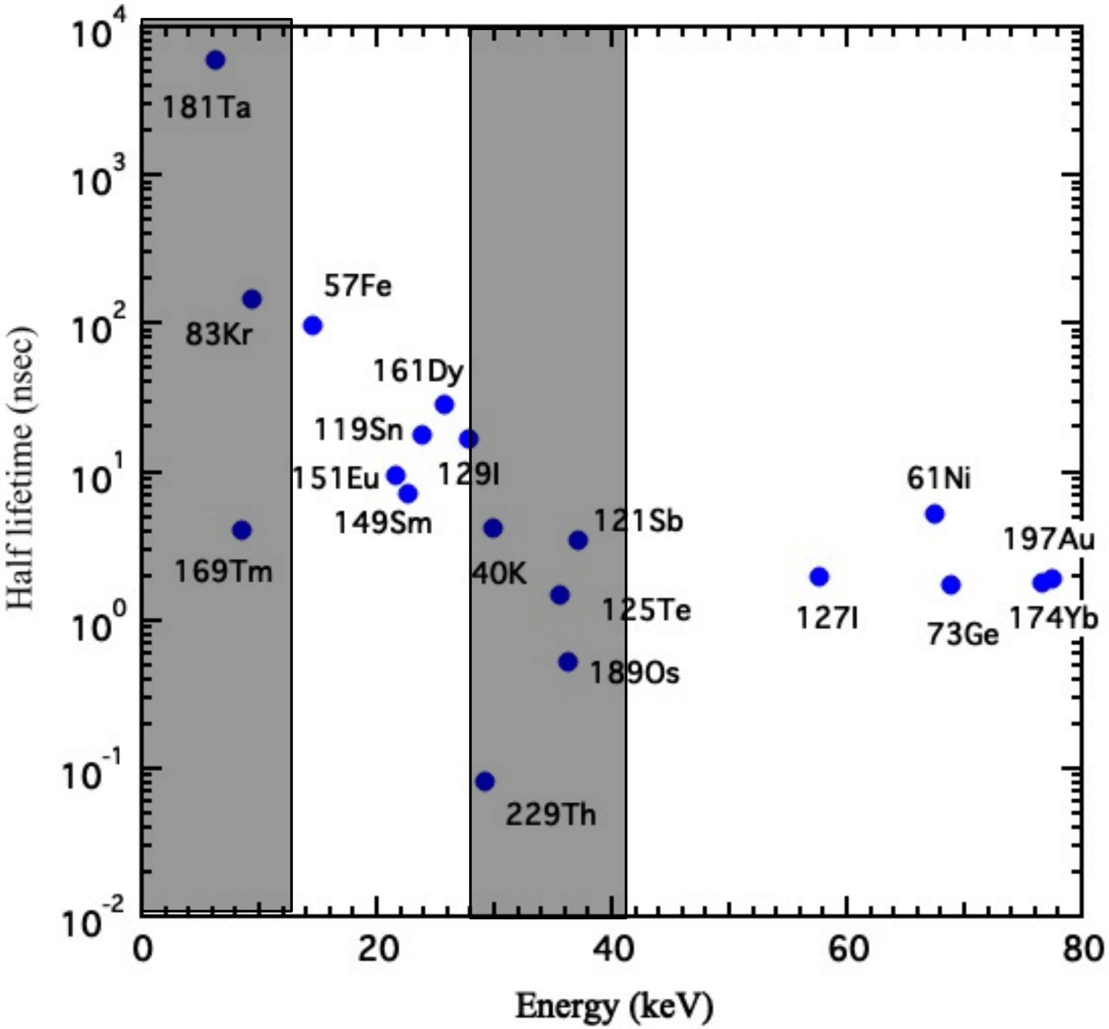
Flux density at BL09XU and BL35XU



By SPECTRA (Tanaka-san)

More than twice flux at ^{57}Fe: 14.4 keV
Higher flux at ^{151}Eu: 21.5 keV, ^{149}Sm: 22.5 keV, ^{119}Sn: 23.9 keV
More than twice flux at over 76.5 keV such as ^{174}Yb: 76.5 keV

Blank in the spectra at BL35XU



Not available at BL35XU

^{181}Ta 6.2 keV
^{169}Tm 8.4 keV
^{83}Kr 9.4 keV
^{229}Th 29.2 keV
^{40}K 29.8 keV
^{125}Te 35.5 keV
^{121}Sb 37.1 keV
etc.

→ use of BL19LXU except ^{181}Ta

^{161}Ta: No proposals more than 15 years

Expected Flux at BL35XU

Maximum intensity after BL mono.
Gap=6.7 mm for 14.4 keV

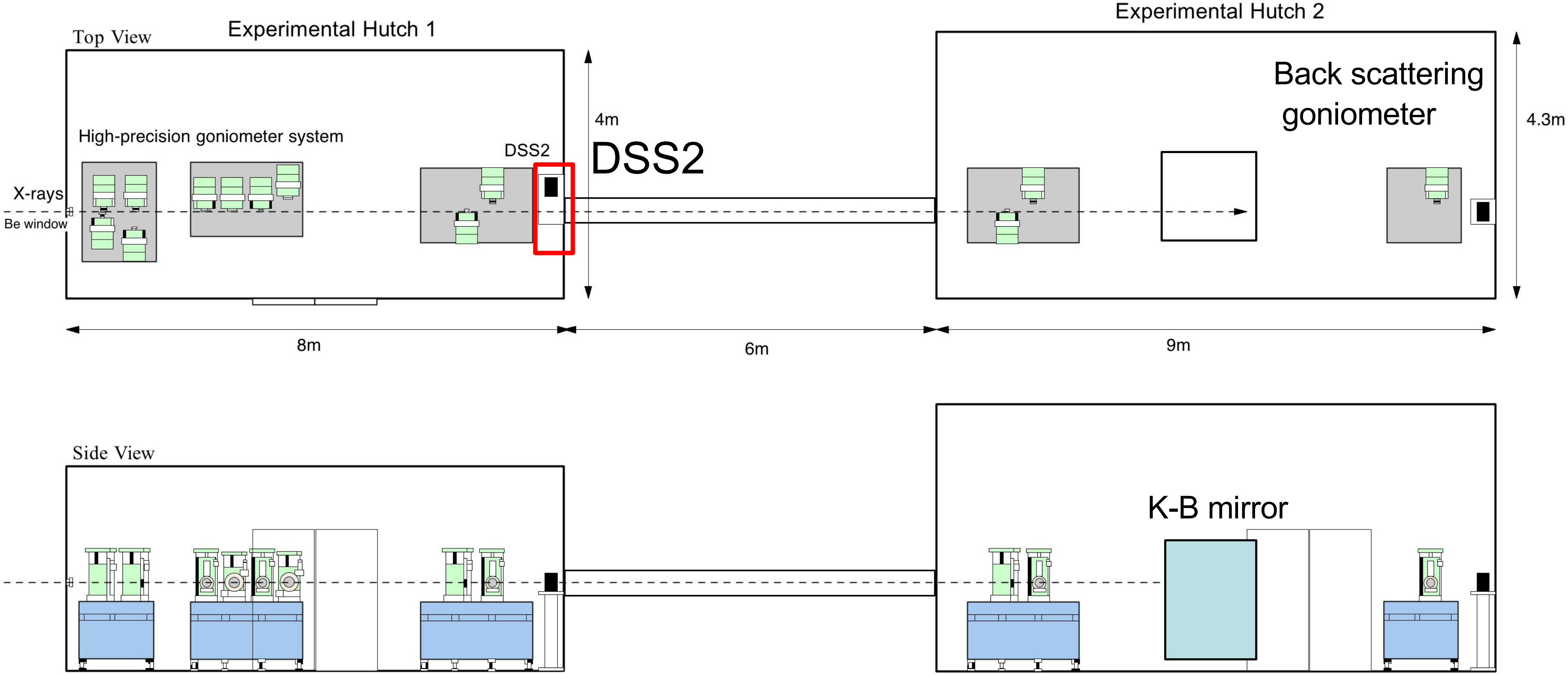
@ FE slit size 0.5 mm (v) × 0.8 mm (h)
c.f. 0.6 mm × 1.5 mm (BL09XU)

- Improvements of Si crystal cooling required
- Lower heat-load at SPring-8 II

BL09XU : Nuclear Resonant Scattering Beamline
(Public Beamline: standard undulator)

High-resolution monochromators and Focusing lens in the Exp. Hutch

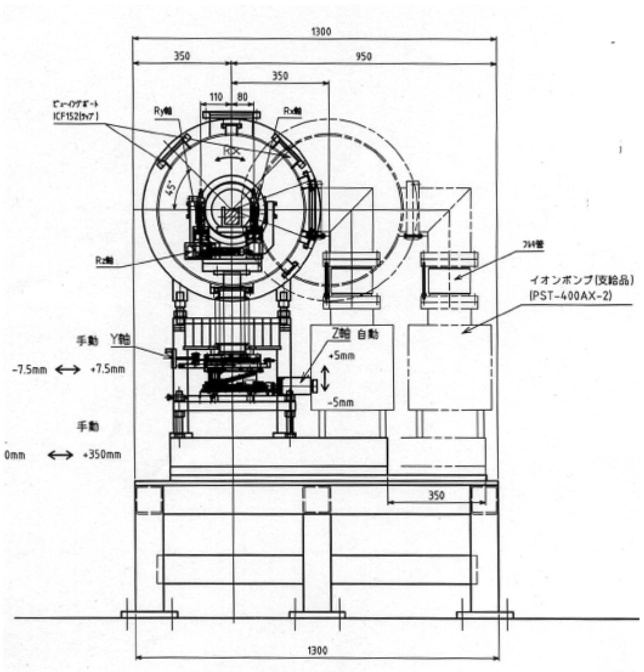
Sample in the Exp. Hutch 2
- cryostat
- superconducting magnet
- Furnas
- goniometer

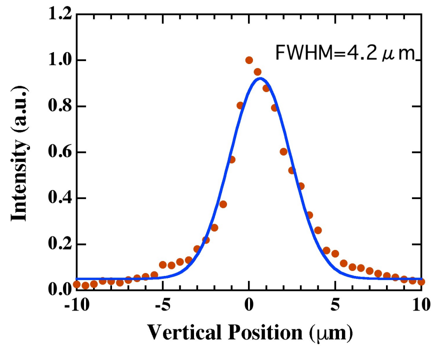


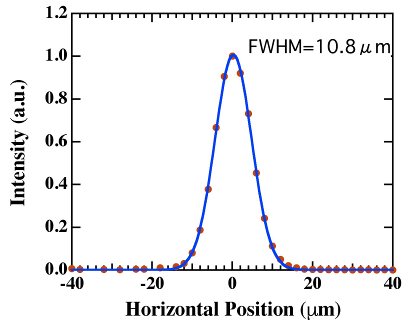
High Resolution Monochromators at BL09XU

Isotope	Eergy (keV)	Reflectiion	Resolution (meV)
^{181}Ta	6.21	Si311 - Si511 - Si511	10.5
^{57}Fe	14.41	Ge331 – Si975 – Si975	0.8
	14.41	Si511 – Si975 (nested)	2.5
	14.41	Si511 – Si975 (nested)	3.5
^{151}Eu	21.54	Si422 - Si12 12 8 (nested)	1.7
^{149}Sm	22.51	Si422 – Si16 8 8 (nested)	1.6
^{119}Sn	23.87	Si440 – Si12 12 12 (nested)	1.6
^{40}K	29.83	Si660 – Si22 14 0	2.6
^{125}Te	35.49	a-Al_2O_3 9 1 -10 68	1.7
^{121}Sb	37.13	Si444 – Si 12 12 8	1.7
^{127}I	57.62	a-Al_2O_3 18 7 -25 98	21
^{61}Ni	67.41	Si866 – Si866	60

KB mirror for HAXPES used for 14.4 keV at BL09XU







Beam size : 4.2μm（V）× 10.8μm（H）

Flux（2.5meV） : 2.6×10^9 cps @14.4 keV

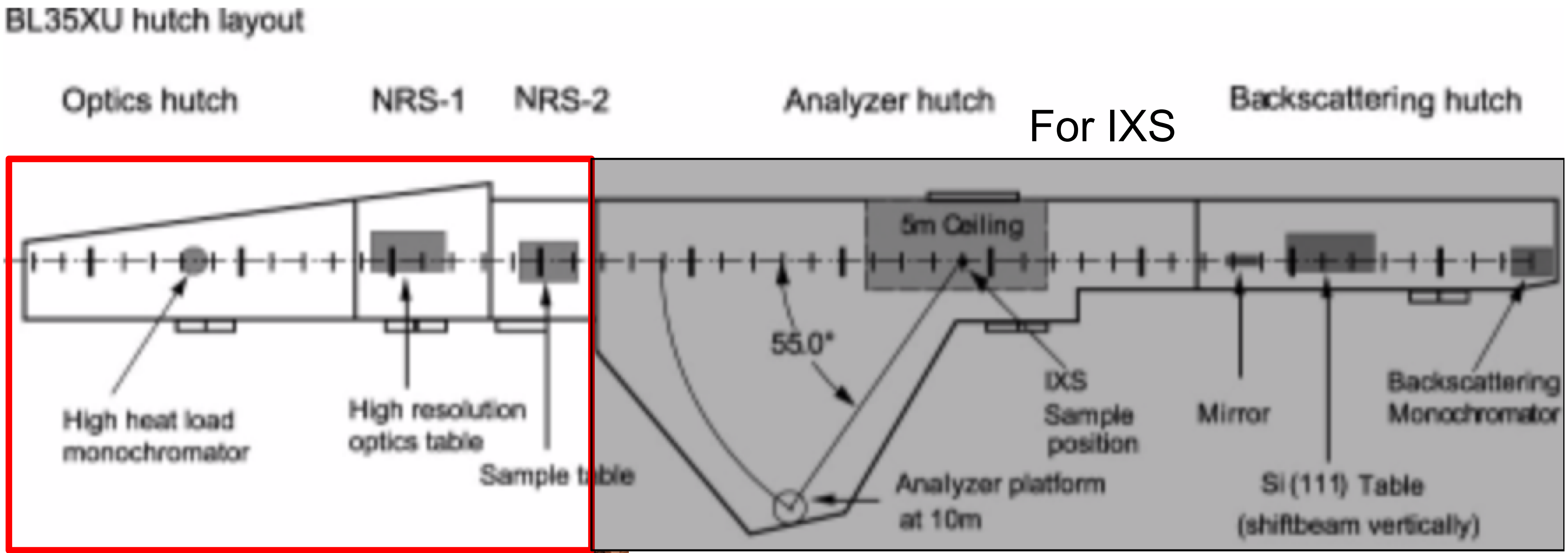
Throughput : 44%

Used for earth science which needs high pressure > 100 GPa.

μm-beam NRS experiments are not so popular at BL09XU

c.f. ESRF, APS, PETRA III

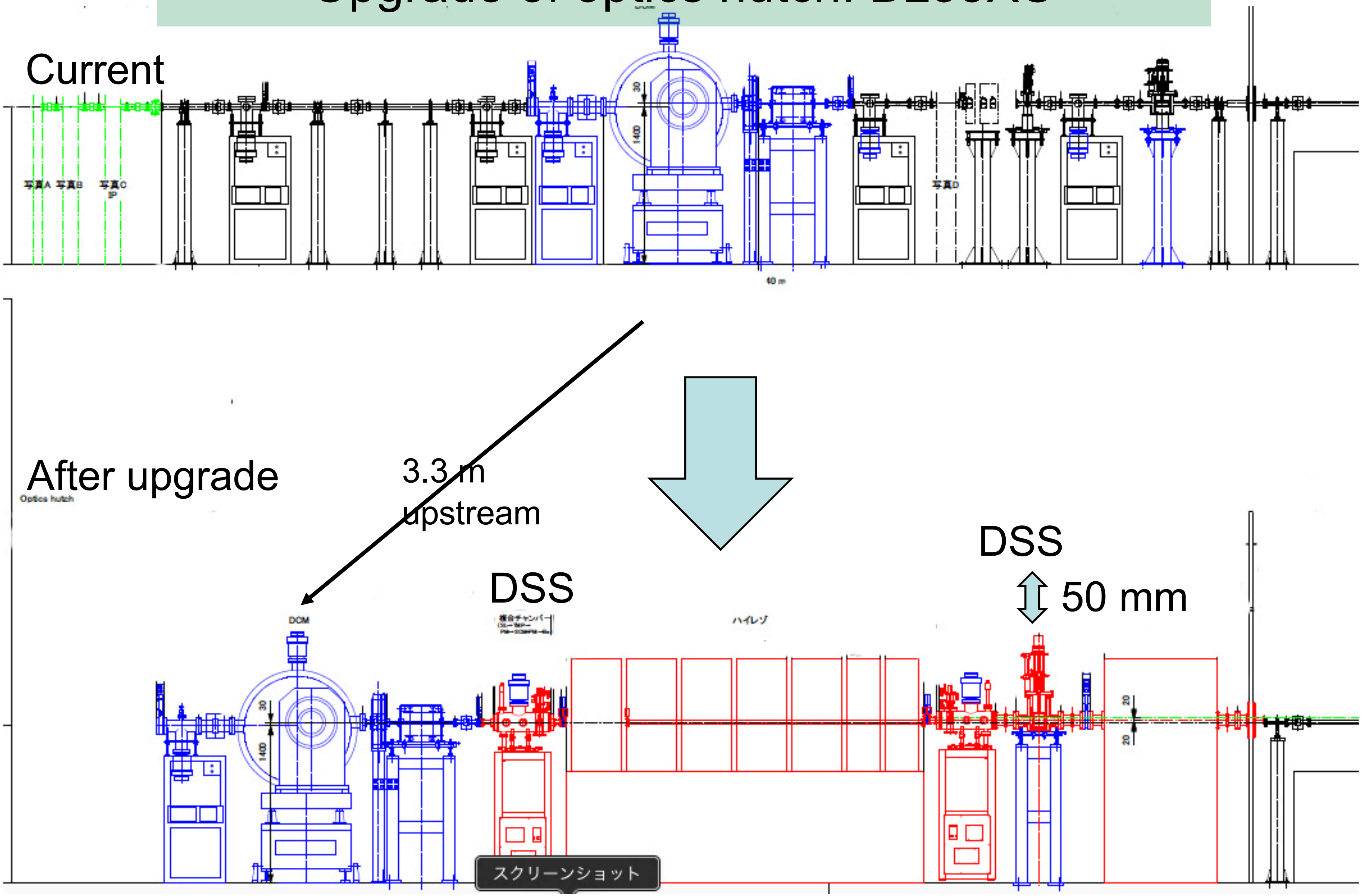
BL35XU



For IXS

Experimental hutch
NRS1
NRS2

Upgrade of optics hutch: BL35XU



・High resolution mono.
・CRLs

Bent cylindrical mirror

Upgrade of optics hutch: BL35XU

High resolution monochromators

Nested type

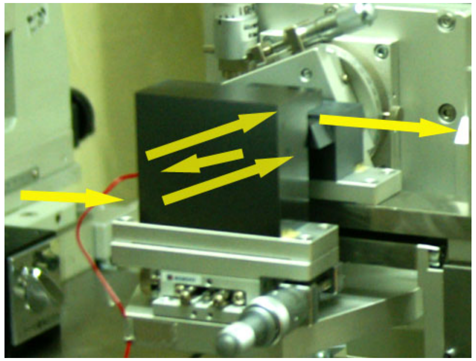
^{57}Fe (2.5 meV & 3.5 meV)

^{57}Fe (6 meV),

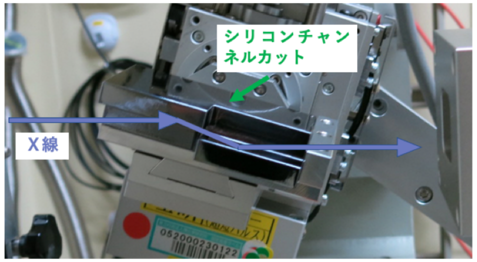
^{151}Eu

^{149}Sm

^{119}Sn



Channel-cut for High energy isotopes



CRLs

1 dimentional focusing for the thin film

Moderate focusing at NRS2

Quick switching between on-line / off-line

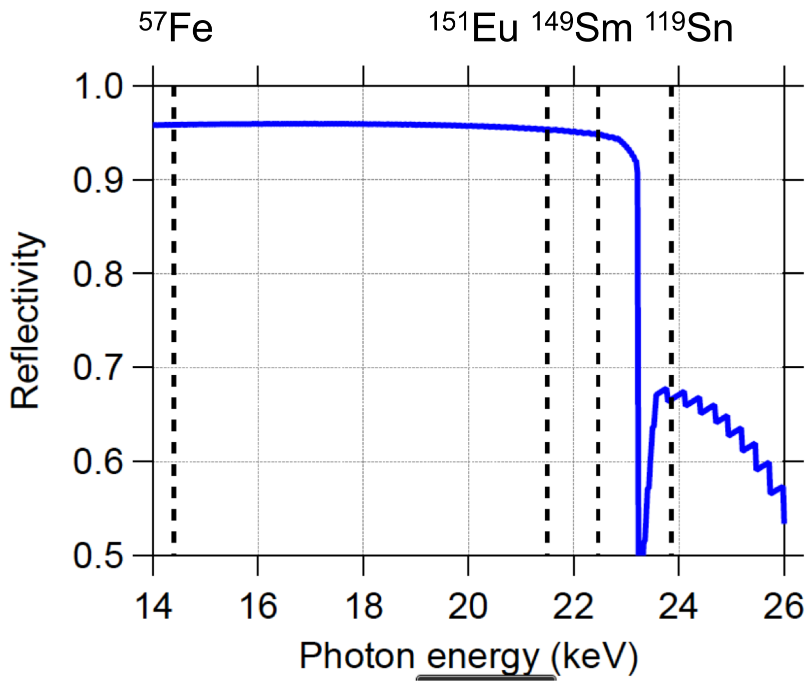
⇨ High throughput

Upgrade of optics hutch: BL35XU

Bent cylindrical mirror

Source – mirror : ~42 m
mirror – focus point : ~3 m
magnification M: ~1/14
Rh coating, 2.5 mrad incident angle

R > 95% for	14.4 keV
	21.5 keV
	22.5 keV
~ 67% for	23.9 keV



High flux μ-beam

W：<~50μm, H：<~30μm
for ^{57}Fe, ^{151}Eu, ^{149}Sm, ^{119}Sn

BL09XU : Nuclear Resonant Scattering Beamline
(Public Beamline: standard undulator)

High-resolution monochromators and Focusing lens in the Exp. Hutch

Sample in the Exp. Hutch 2

- cryostat
- superconducting magnet
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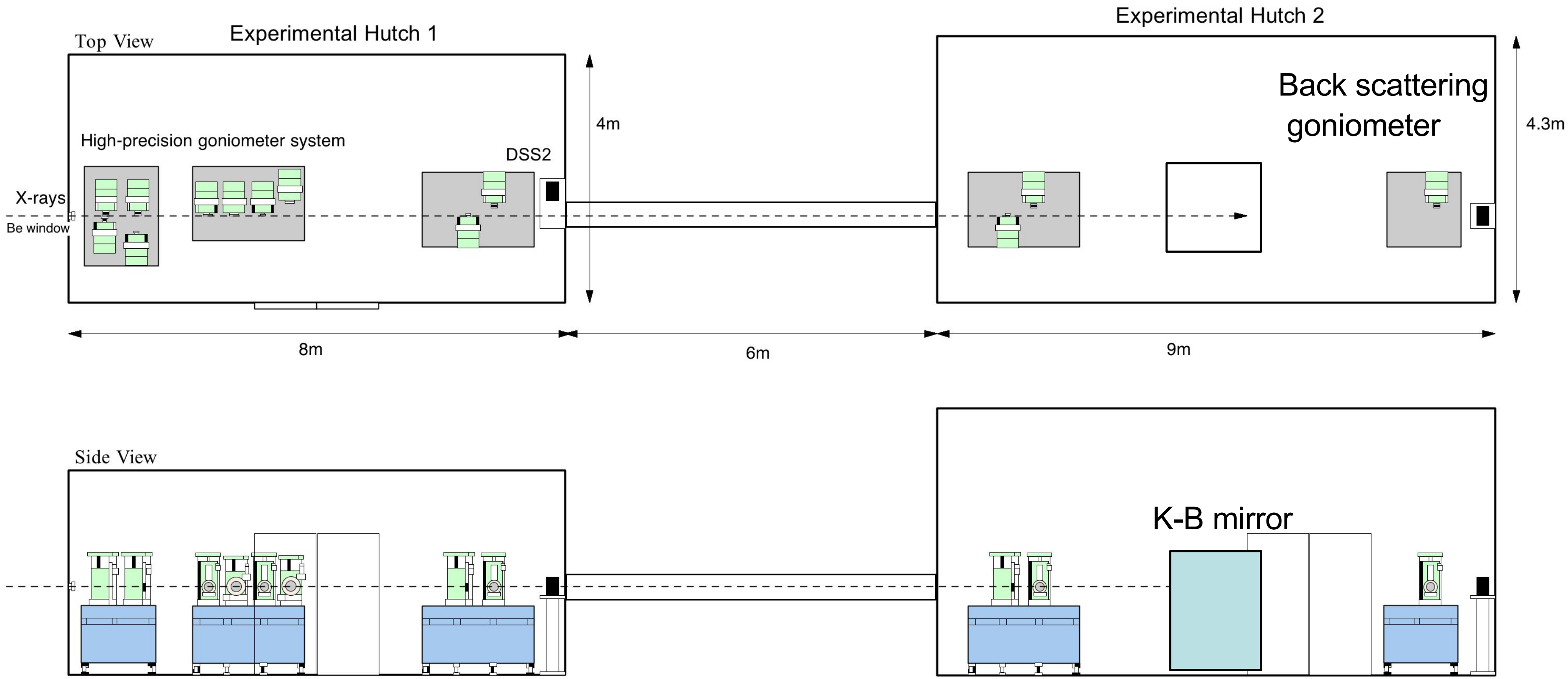
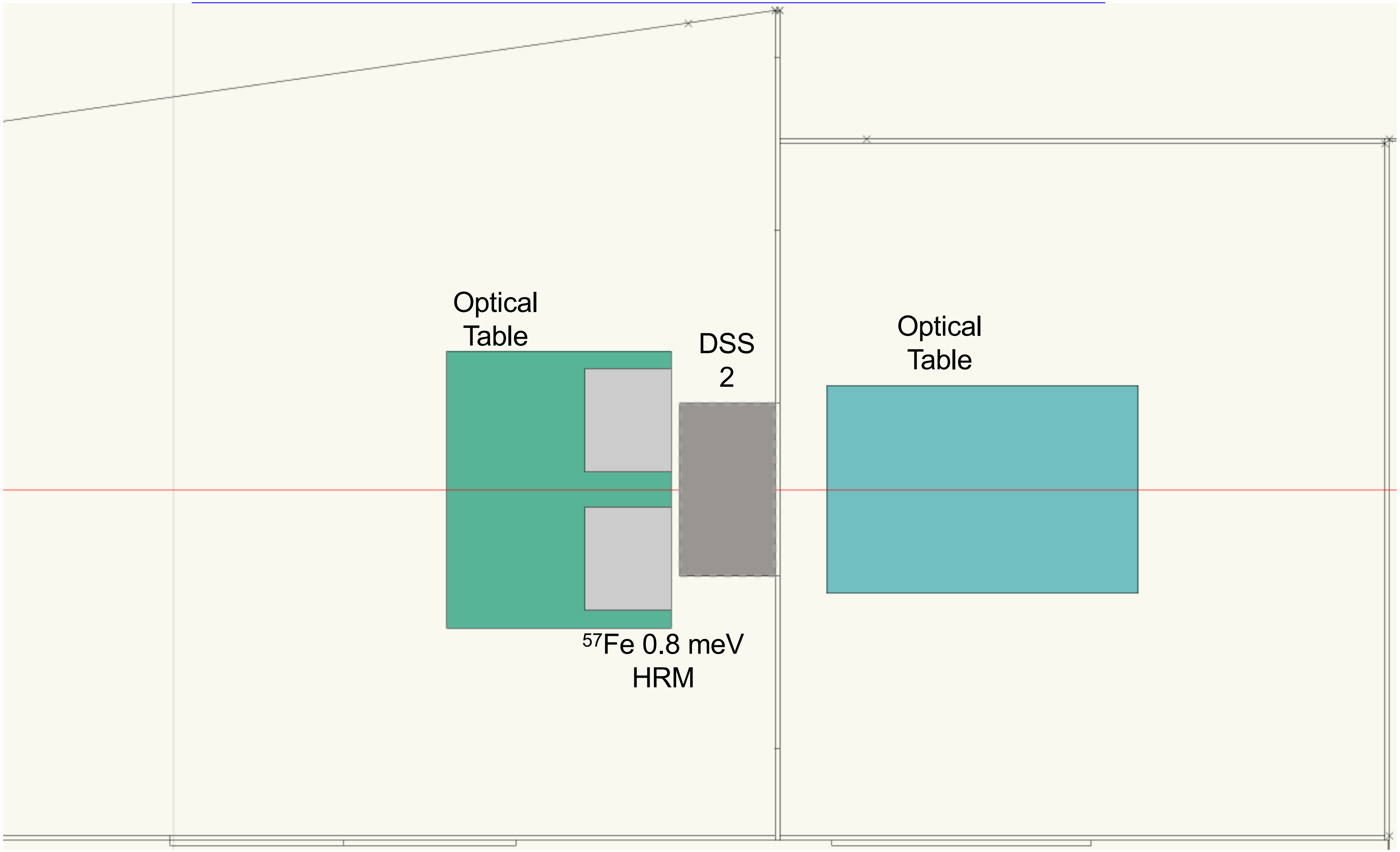
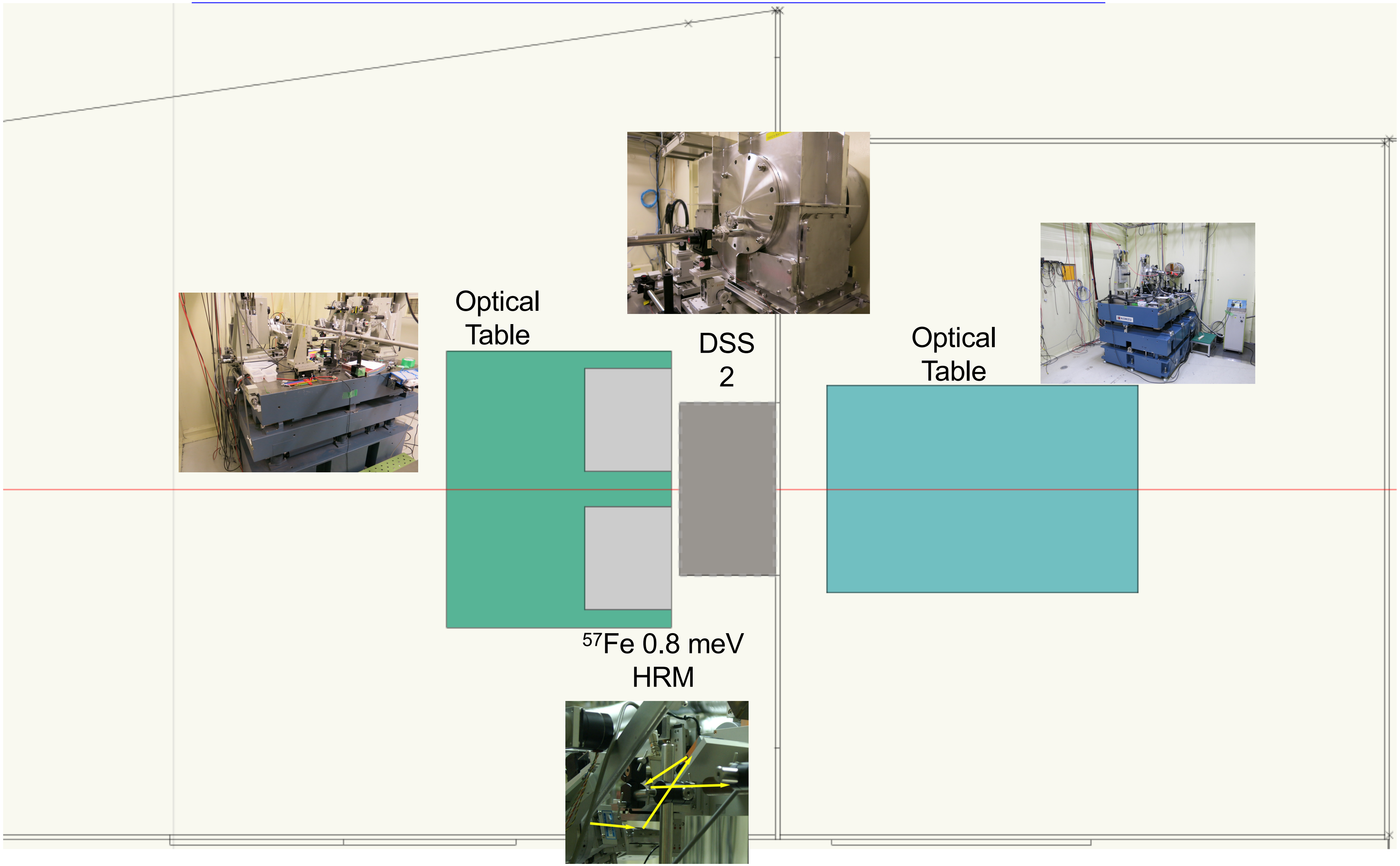


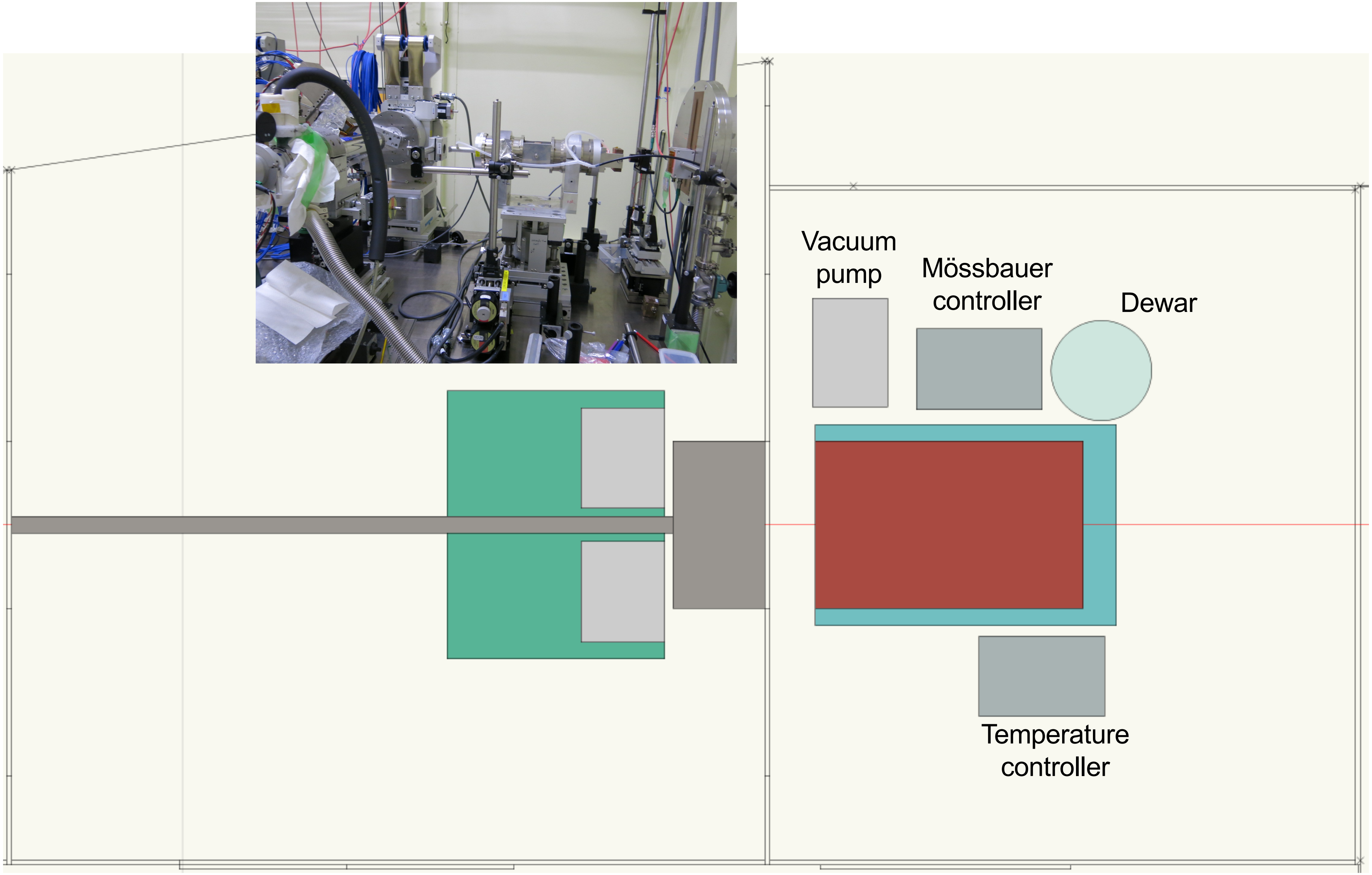
Upgrade of experimental hutch NRS1, NRS2: BL35XU



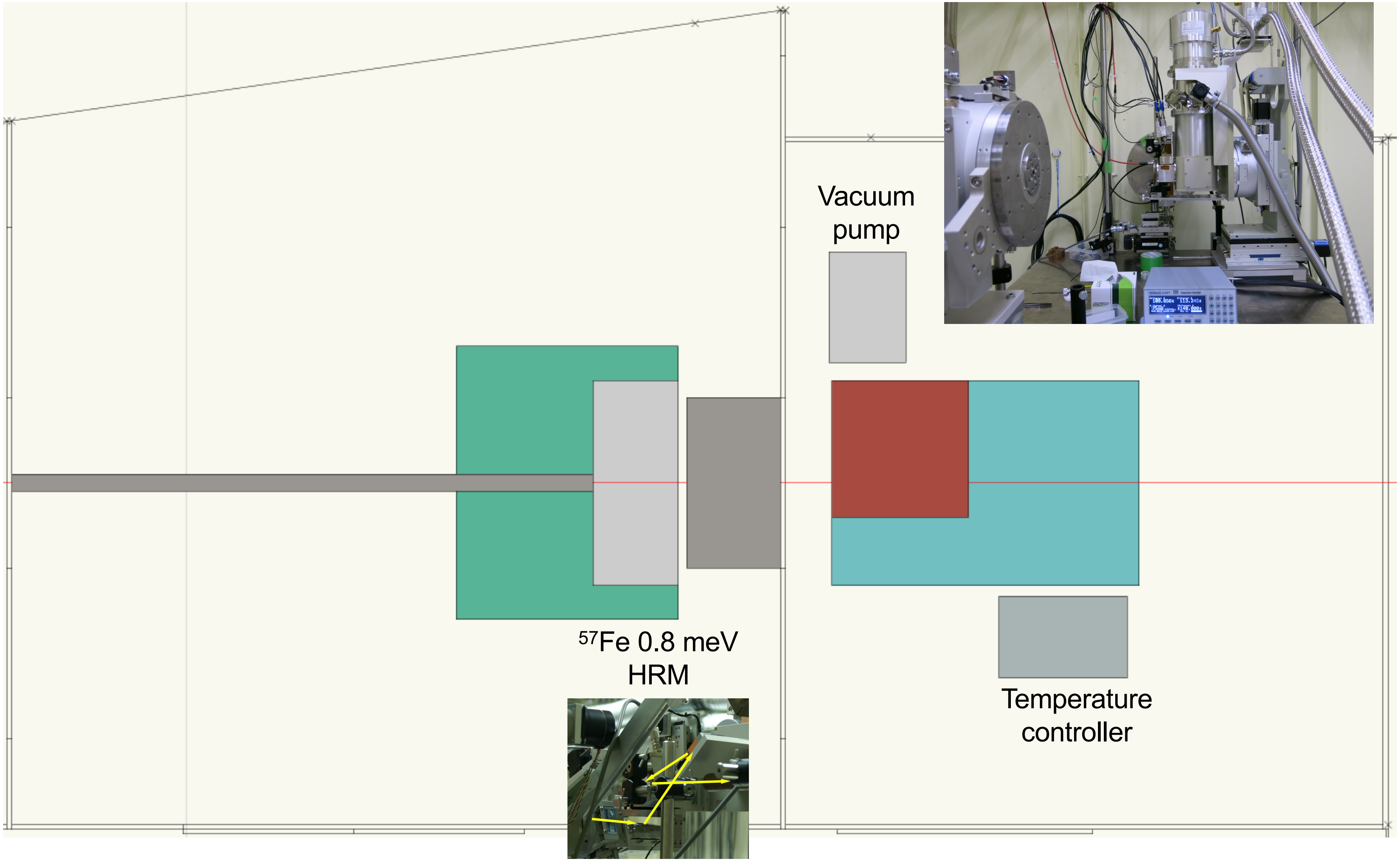
Upgrade of experimental hutch NRS1, NRS2: BL35XU



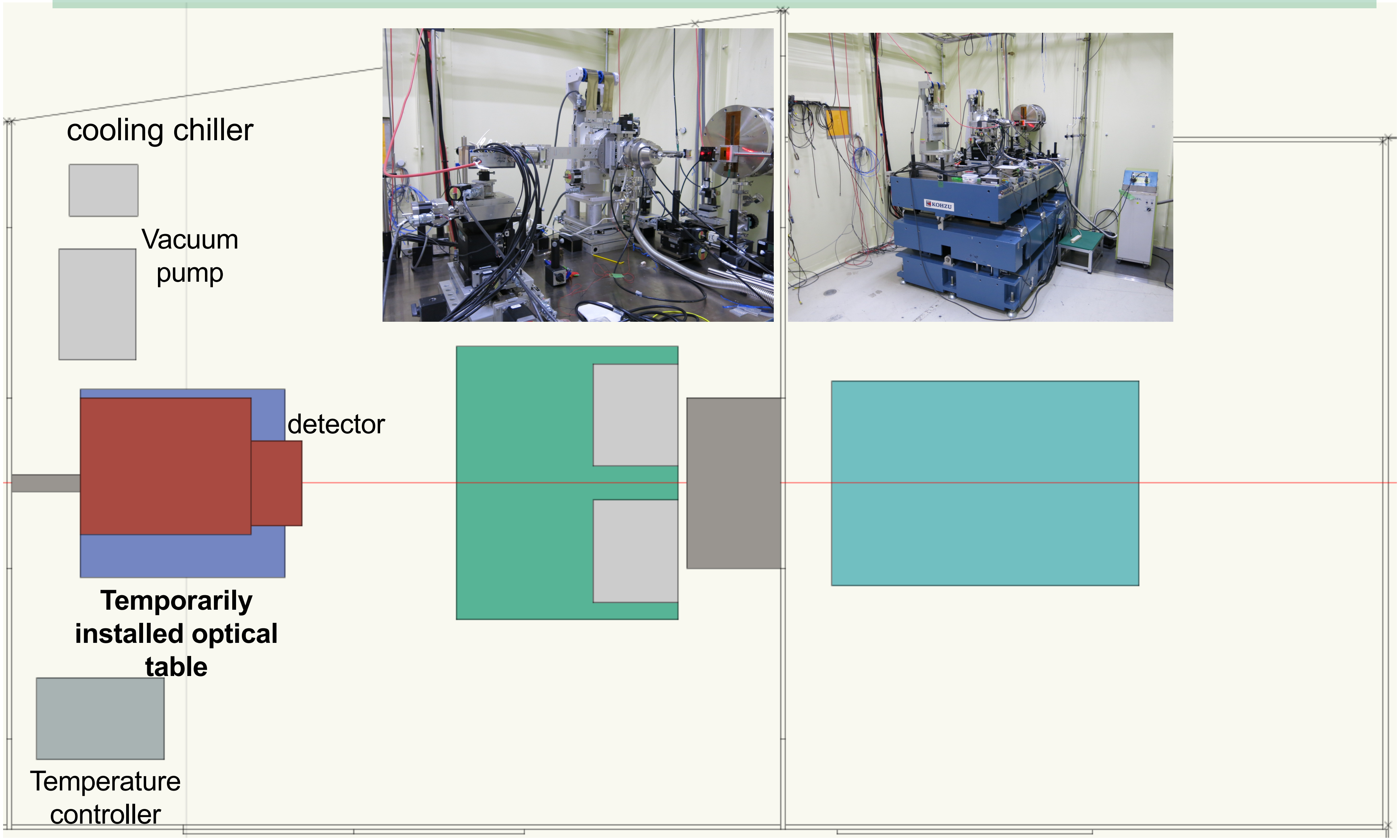
Quasi-elastic scattering at NRS2



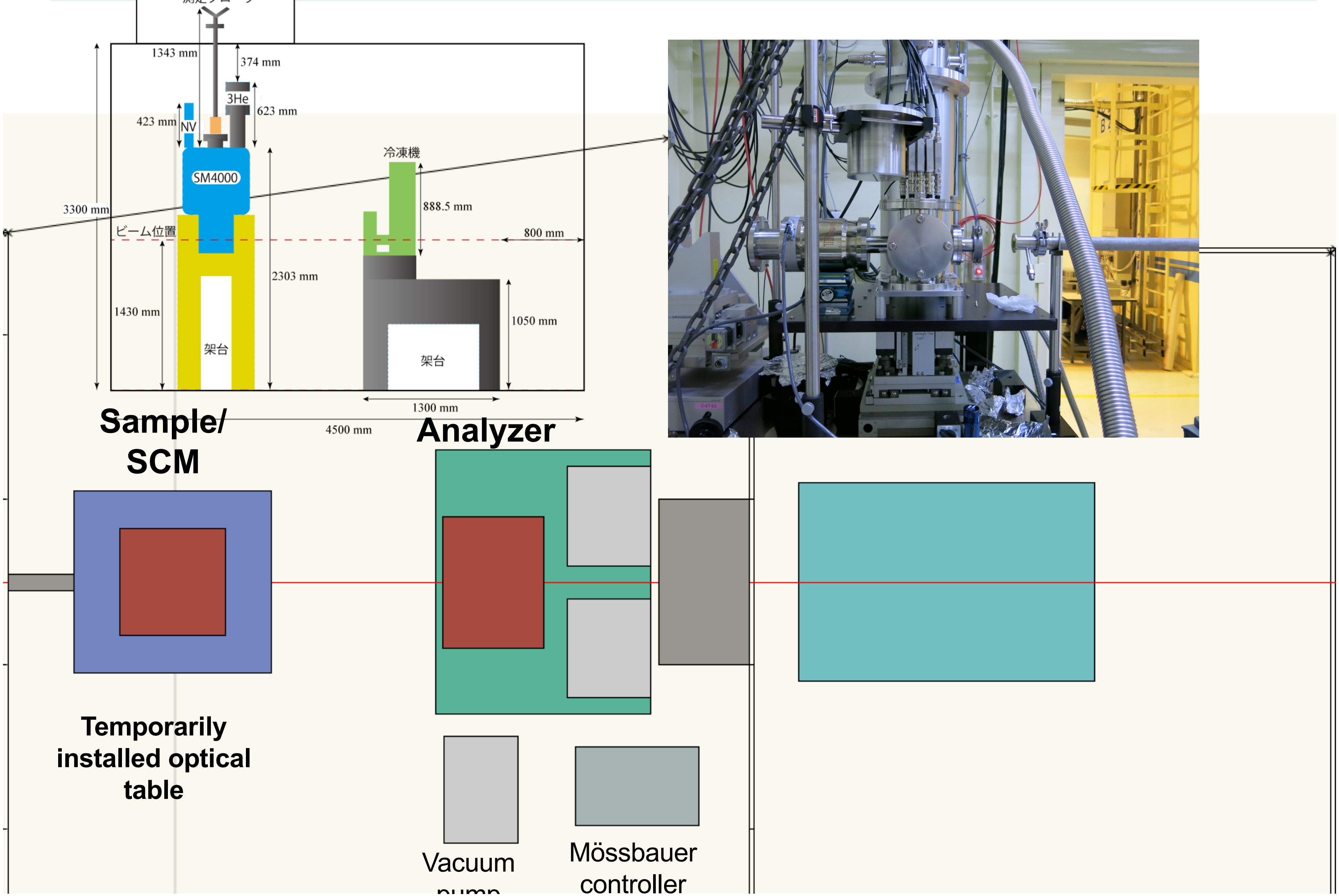
NRVS at NRS2



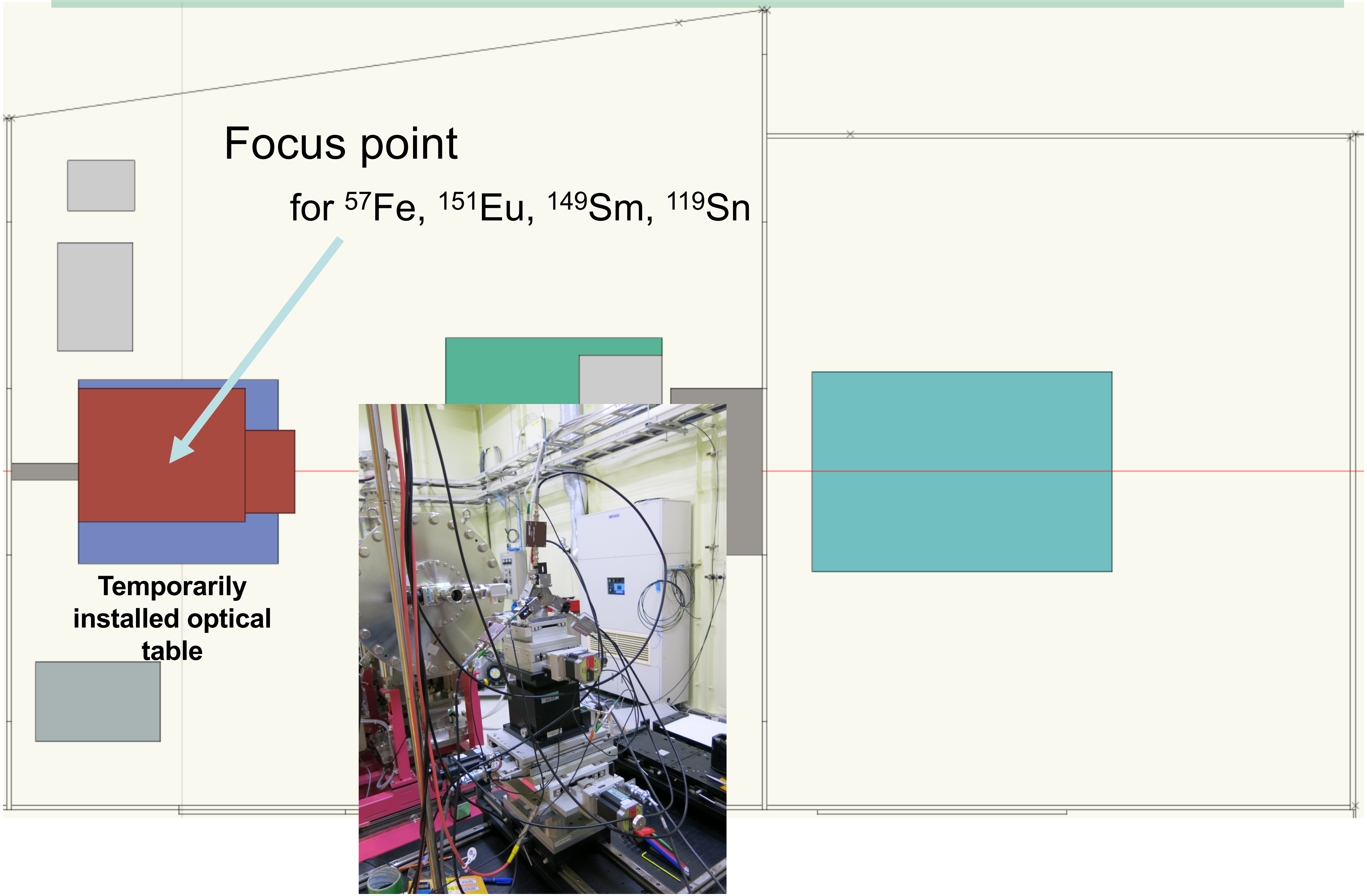
Time domain Mössbauer spectroscopy at NRS1



Energy domain Mössbauer spectroscopy at NRS1



μm-beam Mössbauer / μm-beam NRIX at NRS1



Upgrade of experimental hutch NRS1, NRS2: BL35XU

Quick switching between different techniques

Instruments

Fast electronic circuit

effective use of ultra-fast mcs

⇨
- High accuracy
- High throughput
- Work style reform

Measurements control

same as at BL09XU (LabVIEW based)

Summary

Upgrade points

(1) Higher intensity is expected.

(2) High flux μ-beam is available not only for ^{57}Fe
but also for ^{151}Eu, ^{149}Sm, ^{119}Sn.

(3) High throughput is expected at optics hutch and
experimental hutch

Schedule will be presented by Uchiyama-san.

NRS利用高度化WG
WG for the promotion of NRS research

Member:

Dr. MItsui（BL11XU）

Dr. Tamasaku（BL19LXU）

Dr. Uchiyama（BL35XU）

Prof. Seto（user）

Observer:

Dr. Yabashi

Dr. Sakurai

Dr. Kimura

Dr. Ohashi

Dr. Baron

Engineering support:

Dr. Sugahara