IAC 2023

Overview of 10 Priority Beamlines for 4GSR and Construction States

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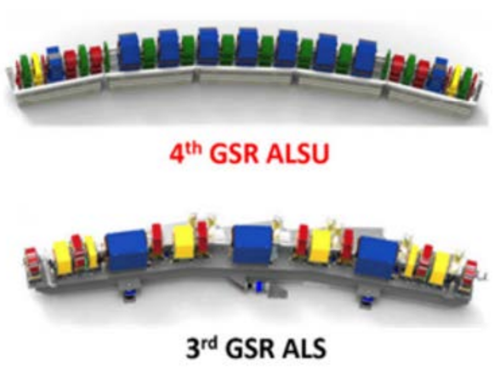
POHANG ACCELERATOR LABORATORY
4GSR 구축지원단

Outline

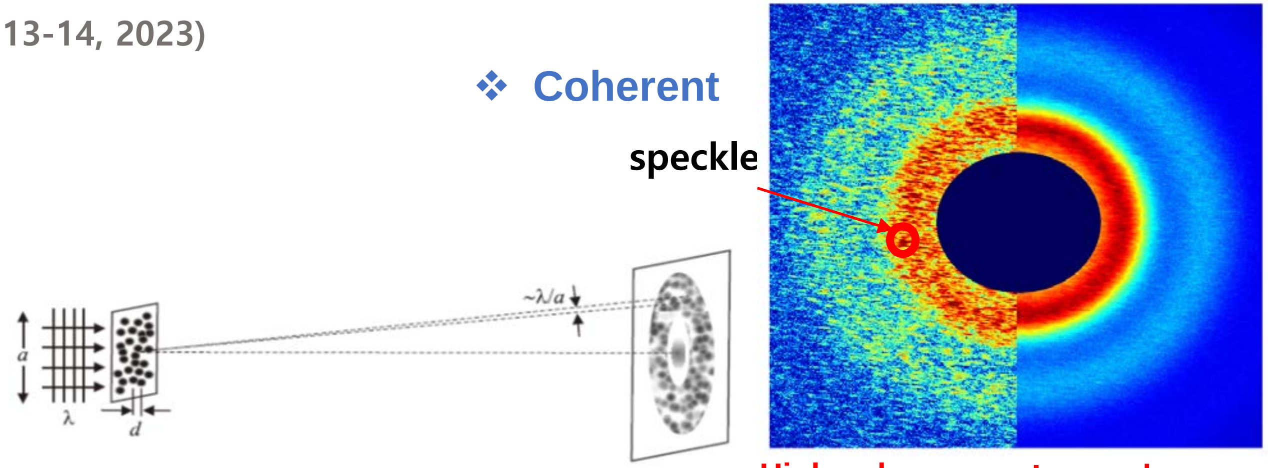
1. Introduction
2. Present status for beamline construction
3. Future Plan
4. Summary

❖ 3GSR, DBA→4GSR, MBA

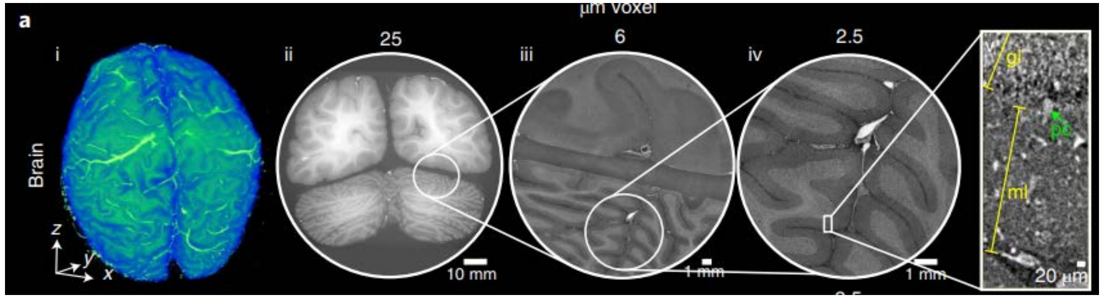


4GSR
- ✓ Brighter
- ✓ More coherent
- ✓ Low emittance

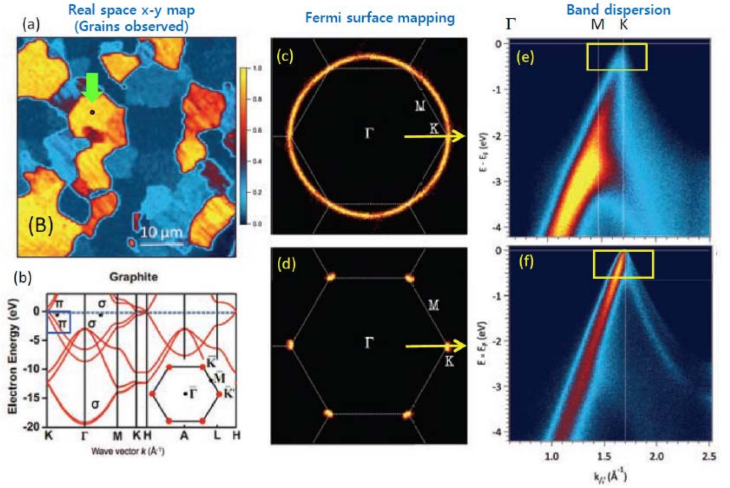
❖ Coherent



❖ High-sensitivity image acquisition through phase-contrast X-ray imaging



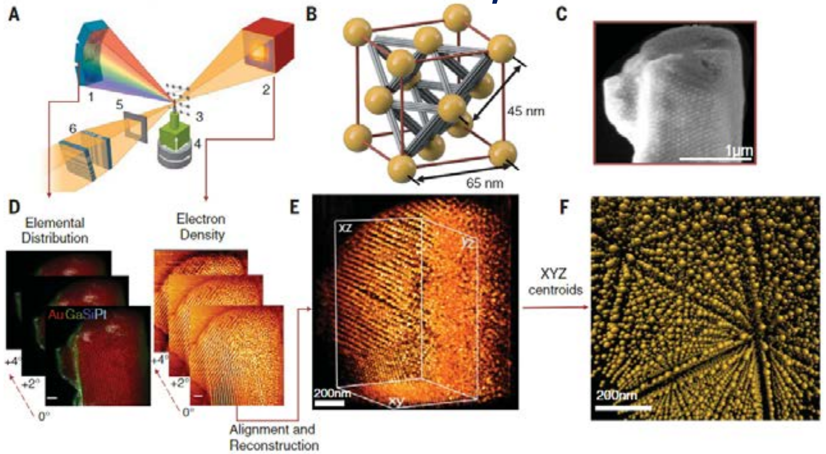
❖ NanoARPES results on HOPG sample obtained with the ANTARES microscope



u-spot ARPES ~ 90 um (multi-domain)

nano-spot ARPES ~ 100 nm (single-domain)

❖ Measurement of 3D lattice, element and strain



4GSR Outline

❖ **Multipurpose Synchrotron Radiation Construction Project**

- Period: 2021 July to 2027 June (6yrs)
- Budget: 1.0454 Trillion KRW (≈ USD 750M)
- Land: 540,000 ㎡ / Building: 69,400 ㎡
- Location: Ochang, Chungcheongbuk-do

Specifications

- Beam Energy: 4 GeV
- Beam Emittance: less than 100 pm·rad (CDR: 58 pm·rad)
- Circumference: 800m
- Beamlines : more than 40
- Accelerator: Gun, Injector LINAC, 4 GeV Booster
- Lattice: MBA-7 Bend Achromat

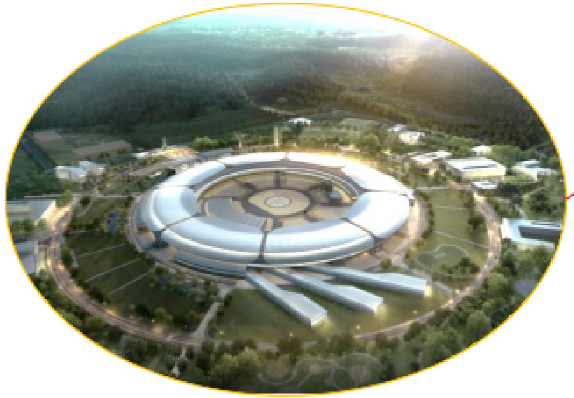
Beamlines in Phase-I

Priority support for industries

① BioPharma-BioSAXS
② Material Structure Analysis
③ Soft X-ray Nano-probe

Support for Academic R&D

④ Nanoscale Angle-resolved Photoemission Spectroscopy
⑤ Coherent X-ray Diffraction
⑥ Coherent Small-angle X-ray Scattering
⑦ Real-time X-ray Absorption Fine Structure
⑧ Bio Nano crystallography
⑨ High Energy Microscopy
⑩ Nano-probe



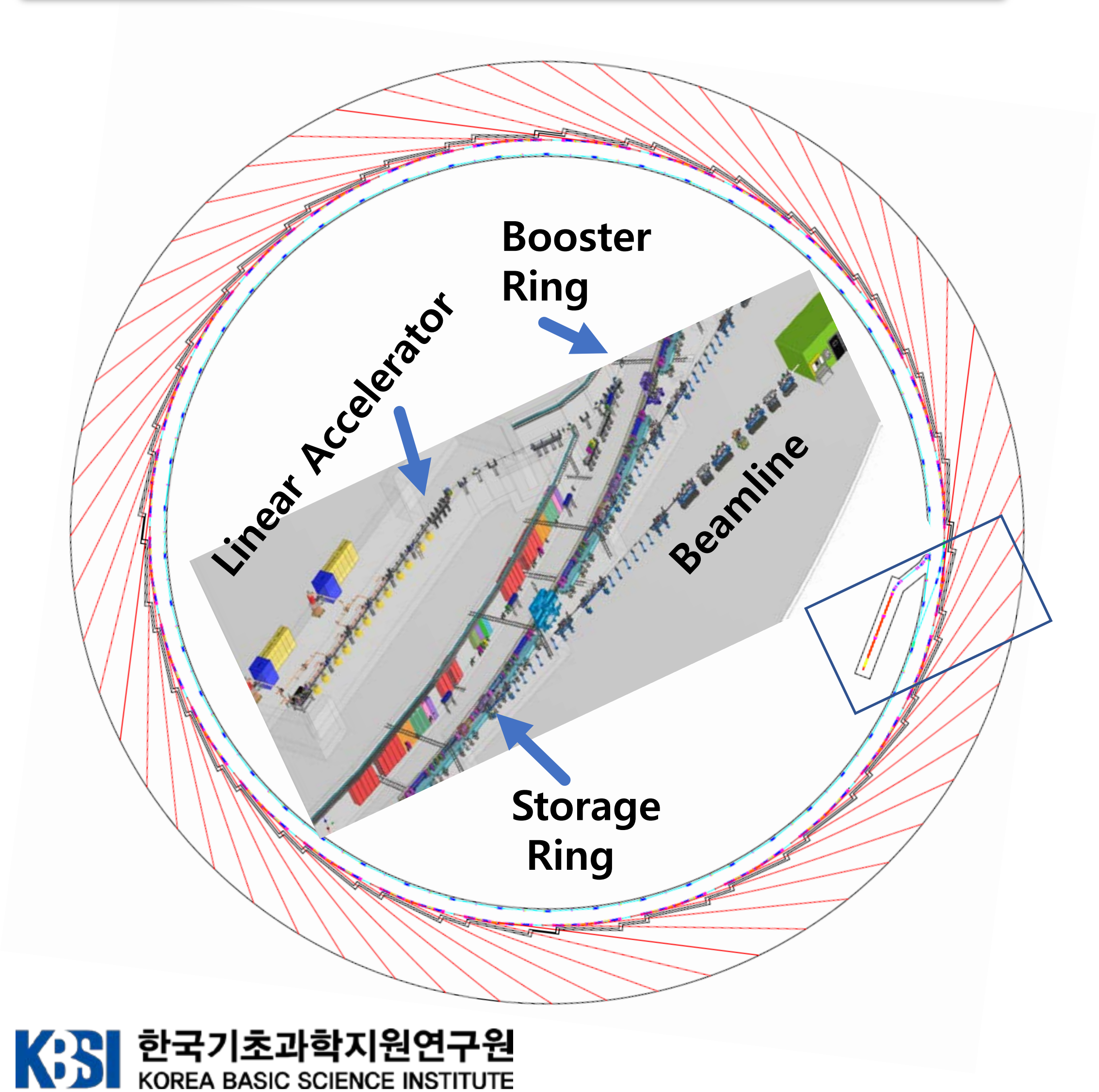
PAL POHANG ACCELERATOR LABORATORY

Priority support for industries

Support for Academic R&D

Beamline	Photon Energy	Resolution	Photon Source	Exp.	Application
① **BioPharma-BioSAXS**	5~20 keV	SAXS: 1 Å 이하 ΔE/E < 10^{-4}	IVU	① Bio-SAXS	Bio.
② **Material Structure Analysis**	5~40 keV	ΔE/E < 10^{-4}	Undulator	① XRD ② XAFS	Material Science, Energy material
③ **Soft X-ray Nano-probe**	0.1~5.0 keV	sub-micro beam ΔE/E>1.5×10^{-4}@1keV	EPU	① XAS ② XPS	Semiconductor, Material Science
④ **Nanoscale Angle-resolved Photoemission Spectroscopy**	0.1~2 keV	100 nm < ΔE/E < 10^{-4}	Undulator	① Nano-ARPES	Semiconductor, Material Science
⑤ **Coherent X-ray Diffraction**	3~30 keV	sub-micro beam	Undulator	① XRD ② CDI	Semiconductor, Material Science Geosciences, Chemistry
⑥ **Coherent Small-angle X-ray Scattering**	4~40 keV	~ a few nm ~ μm ΔE/E < 2×10^{-4}	IVU	① SAXS/WAXS (GI 기법 포함) ② XPCS	Material Science, Chemistry
⑦ **Real-time X-ray Absorption Fine Structure**	5~40 keV	~ a few μm	Undulator	① XAFS	Material Science, Environments, Geosciences, Chemistry
⑧ **Bio Nano crystallography**	5~20 keV	1 Å <	IVU	① MX	Bio.
⑨ **High Energy Microscopy**	5 ~ 100 keV	Spatial R. ~ 0.1μm	Superbend	① Projection imaging	Material Science, Energy material, Bio
⑩ **Nano-probe**	5~25 keV	~50nm NanoProbe 1~10 μm MicroProbe	IVU	① Ptychography/XRF ② XRS	Semiconductor, Material Science, Geosciences, Chemistry, Environments

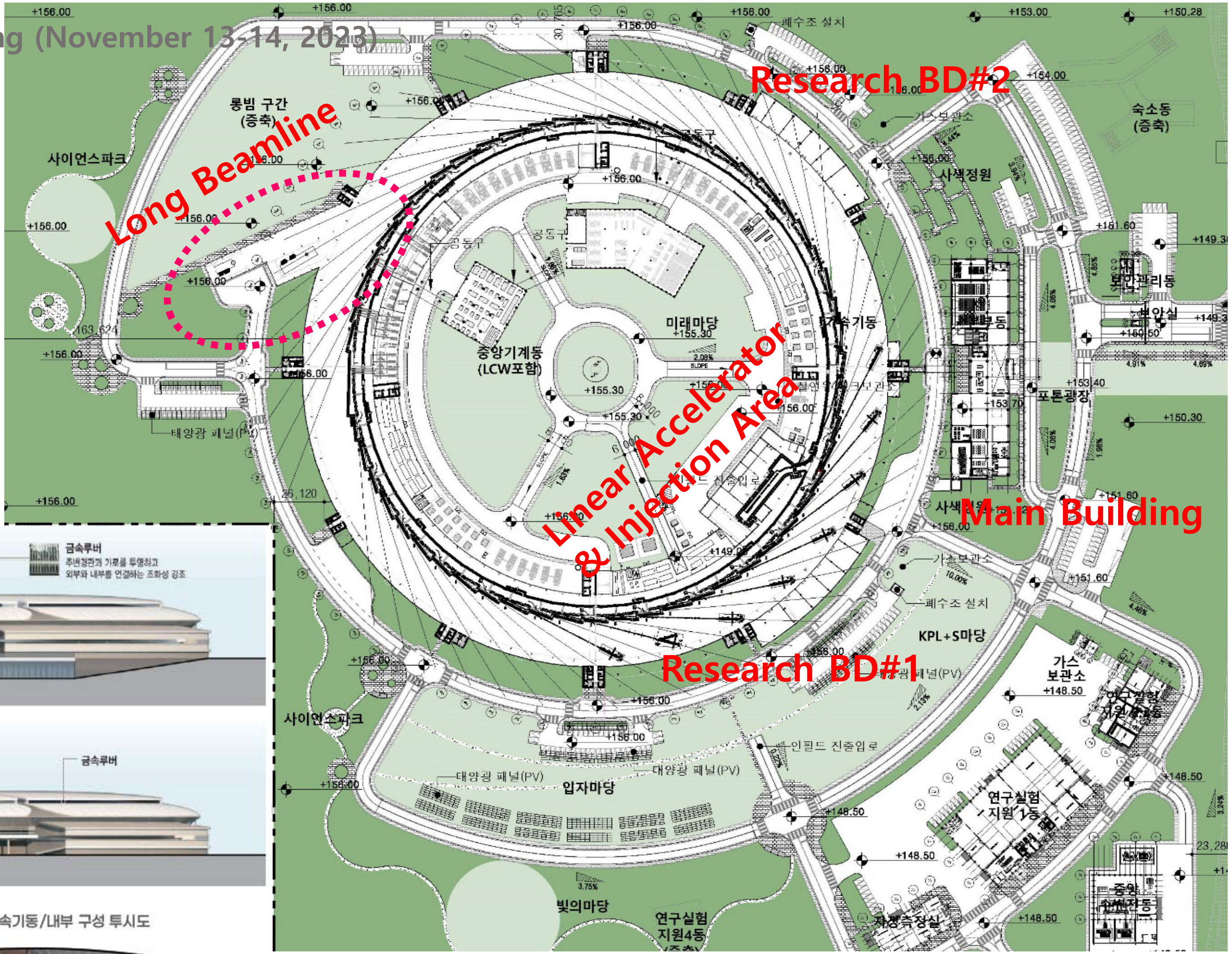
Storage Ring for 4GSR

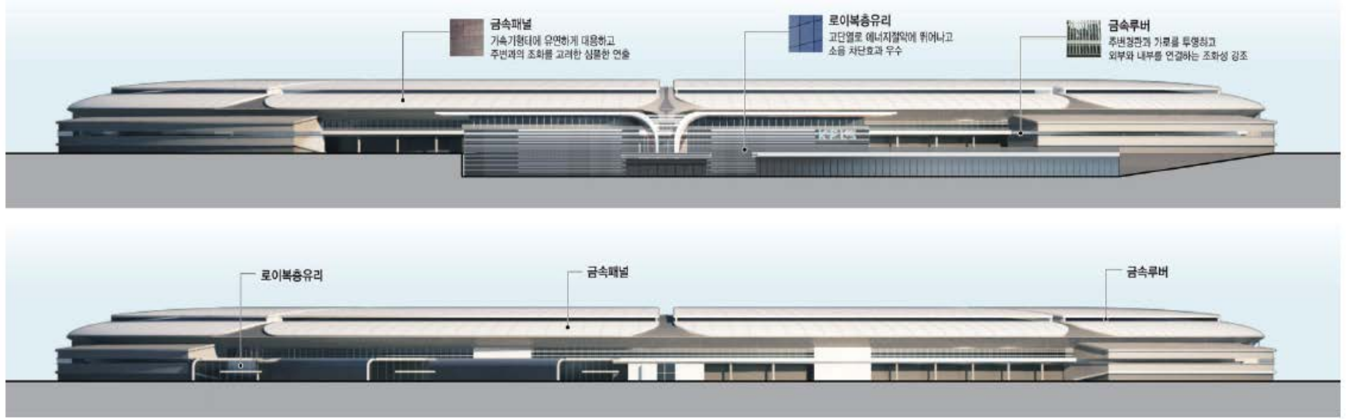


❖ 4GSR Storage Ring Specification

Parameter	4GSR	PLS-II
Beam energy[GeV]	4	3
Beam current[mA]	400 Top-up mode	250(Max. 400), Top-up mode
Circumference[m]	798.8	281.82
Lattice structure	Multi-Bend	Double-Bend
Super-period	28	12
Emittance	62 pmrad	5800 pmrad
RF frequency	499.877 MHz	499.96 MHz
Bunch length[ps]	10.68 (without HC)	20
	53.43 (with HC)	
Number of Bunches	1065	300
Energy spread	0.12%	0.1 %

Ground Plan & Layout





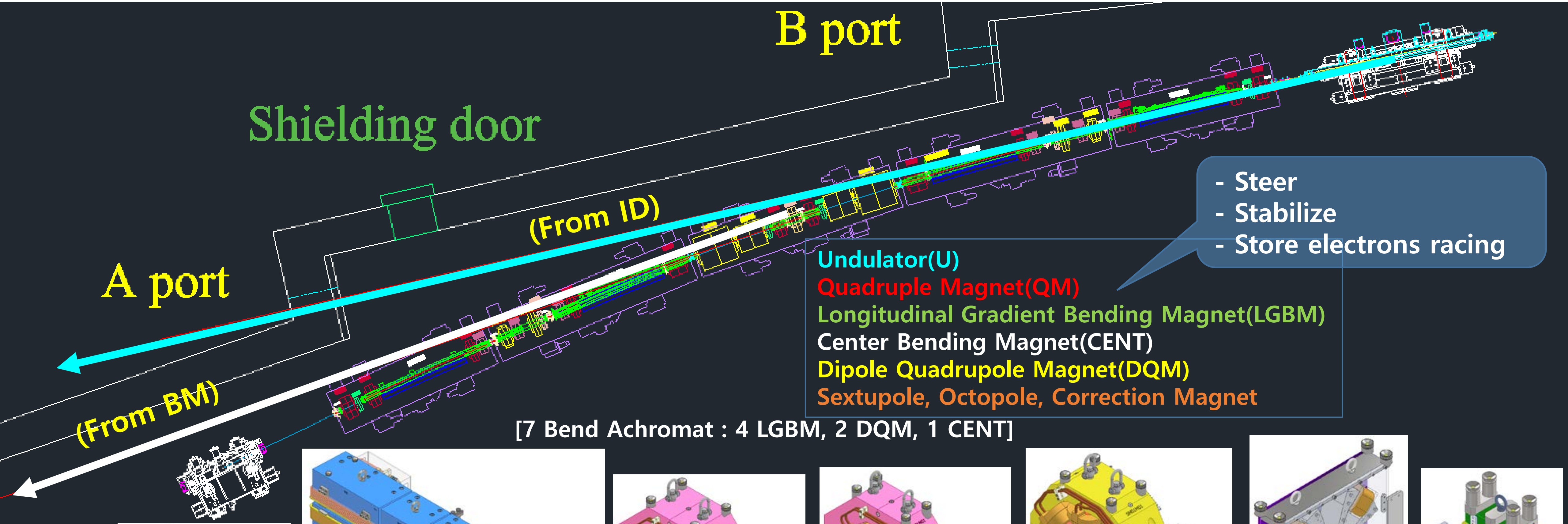
기반시설/본부동/외부 입면도

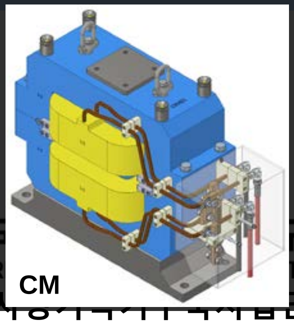
기반시설/가속기동/내부 투시도 기반시설/가속기동/내부 구성 투시도

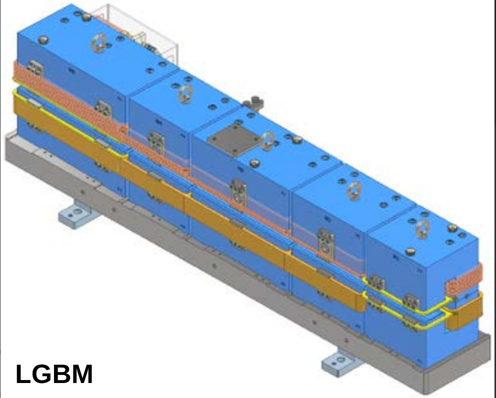
[출처, 다목적방사광가속기 구축사업 기반시설 공모안, (주)행림종합건축사사무소]

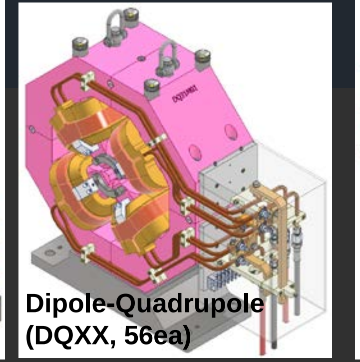
Supercell Structure

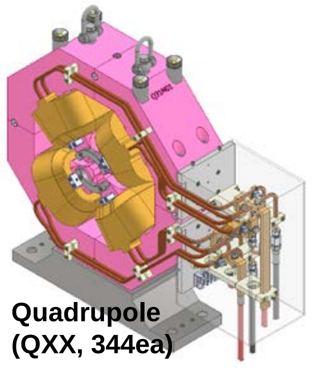
- 28 supercell(12.85°/cell)

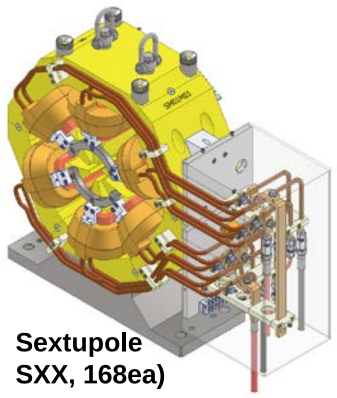


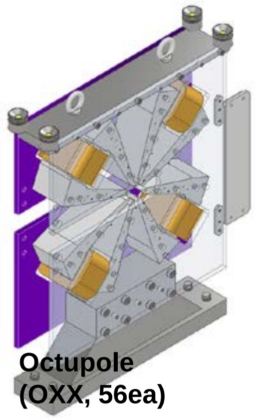

CM


LGBM


Dipole-Quadrupole (DQXX, 56ea)


Quadrupole (QXX, 344ea)

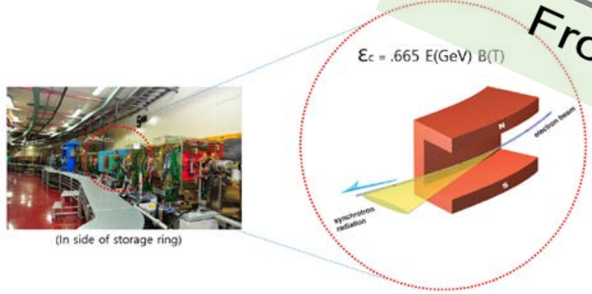

Sextupole SXX, 168ea)

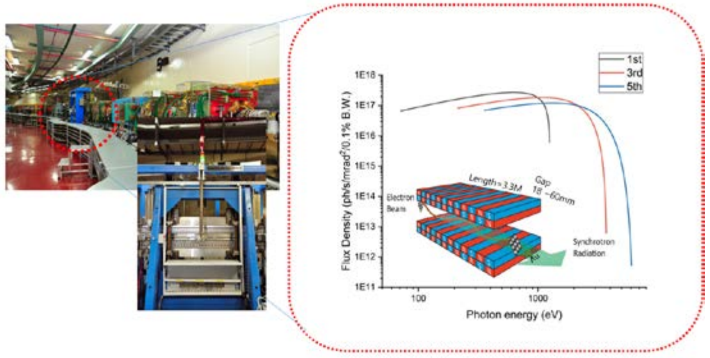

Octupole (OXX, 56ea)


H/V Corrector (CXX, 112ea)

Typical Beamline Layout

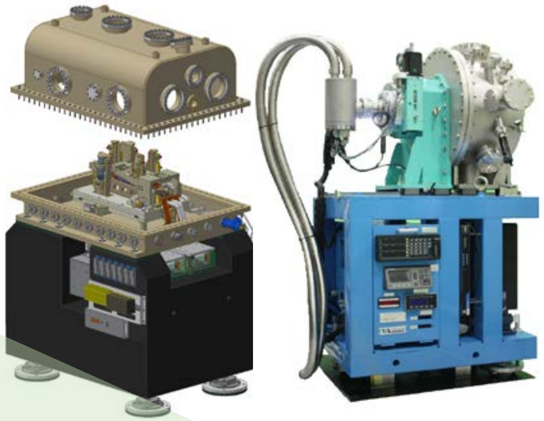
❖ Photon Source
Bending Magnet
Undulator
Wiggler

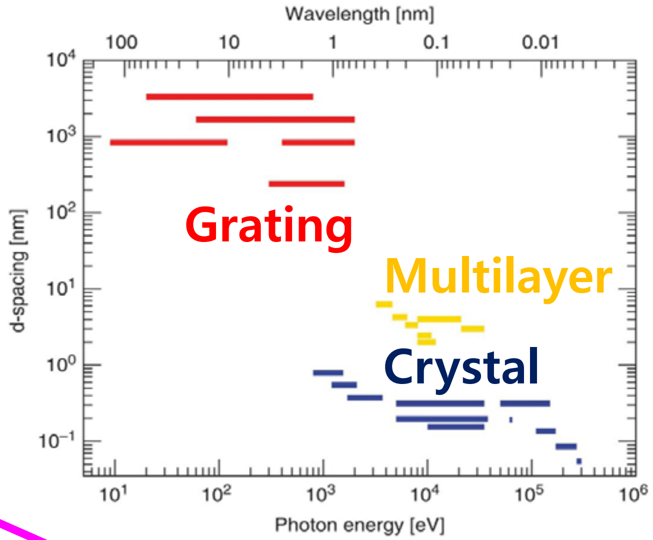


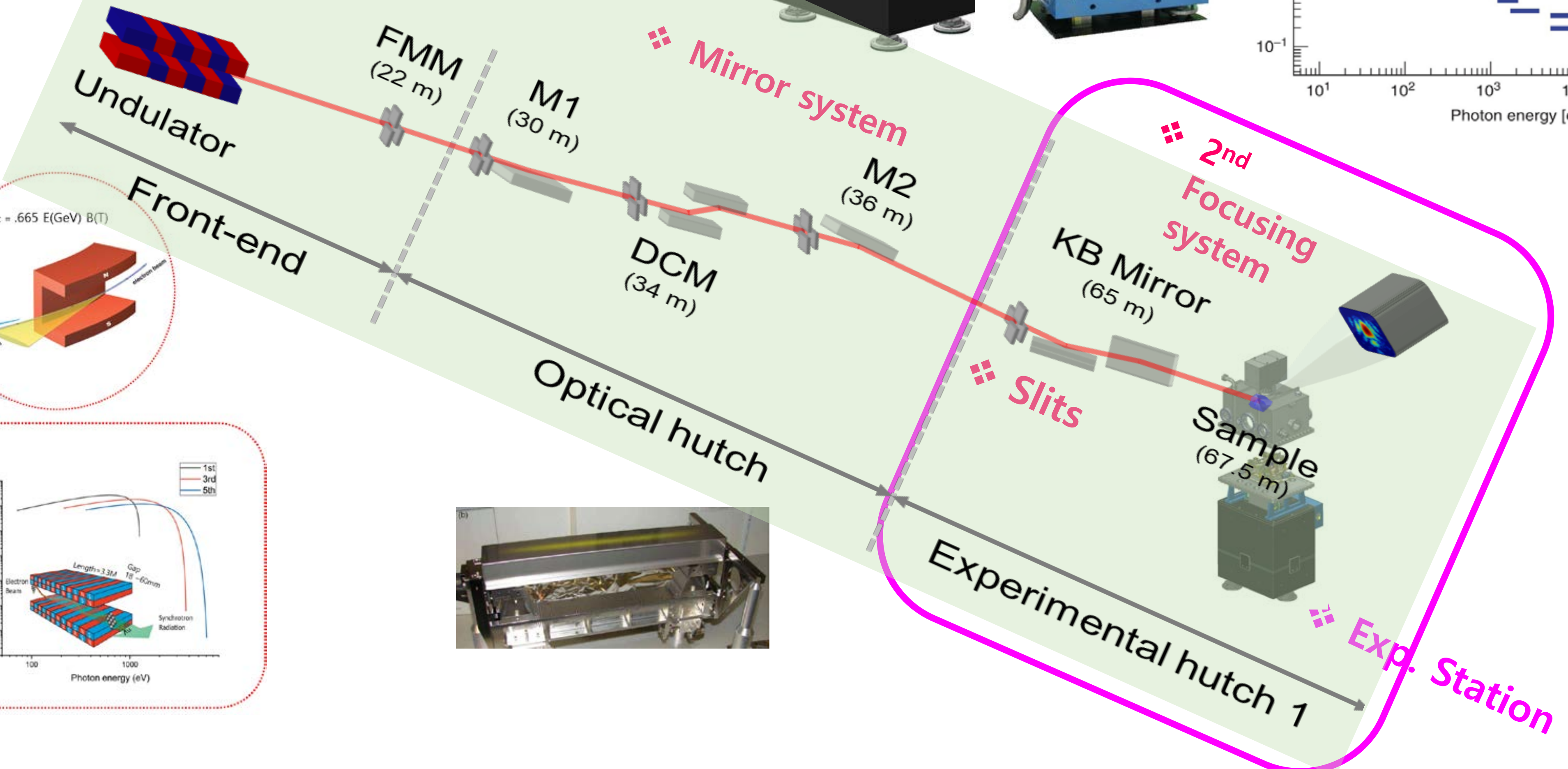


❖ Beam Position Monitor

❖ Different Monochromator Type







Beamline Design

Photon Source
Optical system
Heat Load
Simulation
Stabilization
Safety(personal & Instrument)
User friendly
Budget…

- **Deliver the required X-ray beam to the experiment:**
  - ✓ Energy and bandwidth
  - ✓ Spot size
  - ✓ Divergence/convergence
- **Preserve source characteristics ; intensity, brightness, coherence…**
- **Handle the heat load of the beam**
- **Optimize signal / background**
- **Be very stable and reproducible, in position, intensity and energy**
- **Be safe to operate**
- **Be user friendly to operate**
- **Achieve all the above within a reasonable budget !**

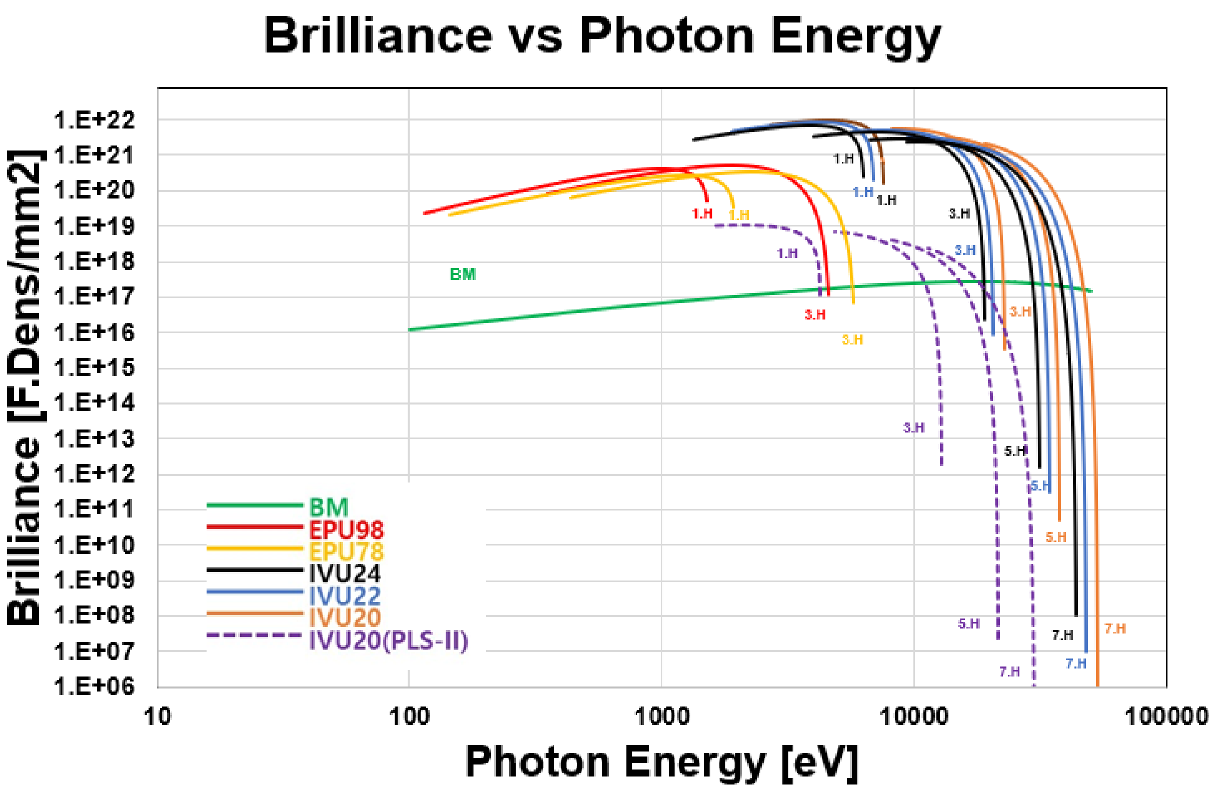
Photon Sources

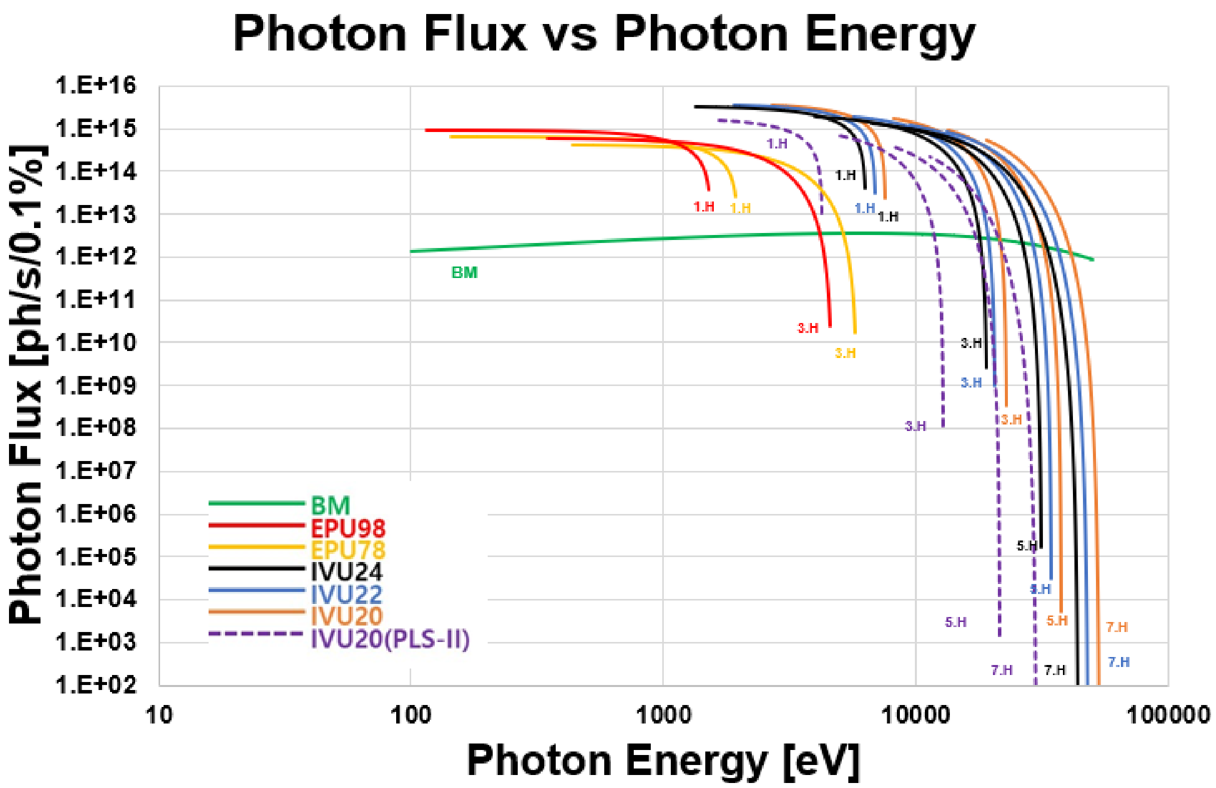
Photon Source	Ty.	Periods length [mm]	Total Length [m]	Photon Energy(keV)	#	Applicable BL	Beam Port
Bending Magnet	BM			5 ~ 100	1	#09. HEMicroscopy	BM10
Out-vacuum Undulator	EPU	78	2	0.1 ~ 3.2	1	#03. Soft X-ray NanoProbe	ID26-1
		98	3.6	0.05 ~ 2	1	#04. NanoARPES	ID25
In-Vacuum Undulator	IVU	20	3	5 ~ 40	2	#06. CoSXAS	ID20
						#08. BioNX	ID22
		24	3	3 ~ 40	5	#01. BioPharma.	ID21
						#02. Mat. Structure	ID24
						#05. CoXRS(CDI)	ID19
						#07. Realtime XAFS	ID23
						#10. NanoProbe	ID10
			1.5	2 ~7	1	#03. Soft X-ray NanoProbe	ID26-2

Properties of Photon Source

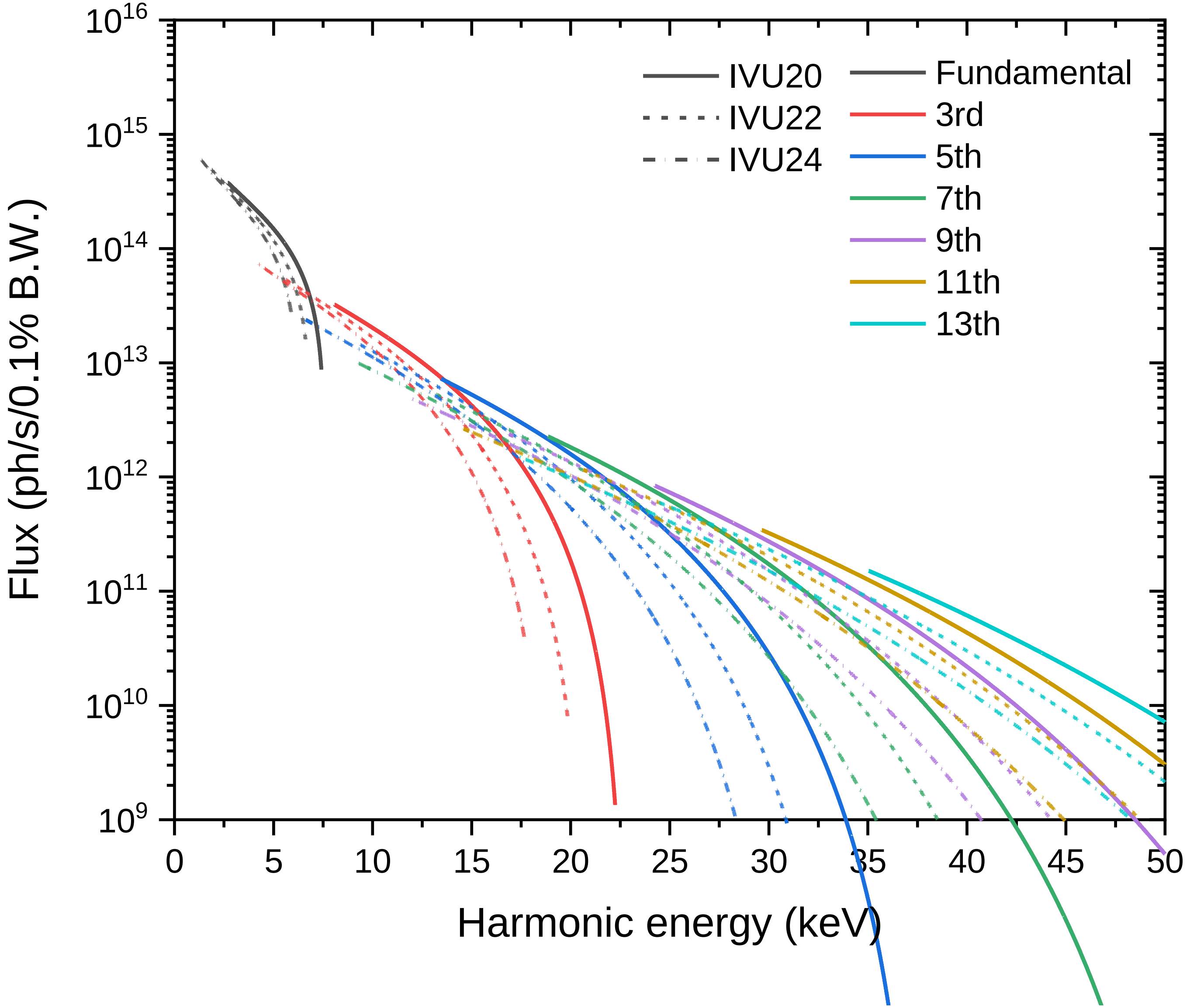
Undulator	(Unit.)	IVU20	IVU22	IVU24	EPU78	EPU98	BM	PLS-II (IVU20)
Period Length	[mm]	20	22	24	78	98	-	20
Periods		148	134	123	23	34	-	68
Device Length	[m]	3	3	3	2	3.62	0.186	1.4
K_{max} value		1.90481	2.3007	2.7458	K_V6.95 K_C4.39 K_H5.65	K_V9.24 K_C6.07 K_H8.05	-	1.811
B_{max}	[T]	1.02	1.12	1.22	B_V0.95 B_C0.60 B_H0.77	B_V1.01 B_C0.66 B_H0.87	2	0.969
Gap_{min}	[mm]	5	5	5	15	15	-	5
ε_{1st}	[eV]	2699.6	1893.9	1327.3	77.48 / 97.28 / 114.84	35.48 / 46.41 / 40.96	[E_c] 21280.8	1618.78
Total Power	[kW]	12.47	14.97	17.94	6.61 / 4.37 / 5.21	13.75 /10.44 / 11.87	1357.83	2.91
Max.Power Density	[W/mrad^2]	164.1	164.1	165.5	24.31	38.06	Lin. Pow. Density (kW/mrad) 0.216	22.5
Max.central cone	[mrad]	$\Sigma_{x'}$ 0.0093 $\Sigma_{y'}$ 0.0089	$\Sigma_{x'}$ 0.0109 $\Sigma_{y'}$ 0.0106	$\Sigma_{x'}$ 0.0129 $\Sigma_{y'}$ 0.0126	$\Sigma_{x'}$ 0.0854 $\Sigma_{y'}$ 0.0854	$\Sigma_{x'}$ 0.0956 $\Sigma_{y'}$ 0.0955		$\Sigma_{x'}$ 0.0341 $\Sigma_{y'}$ 0.0171

Brilliance and Photon Flux



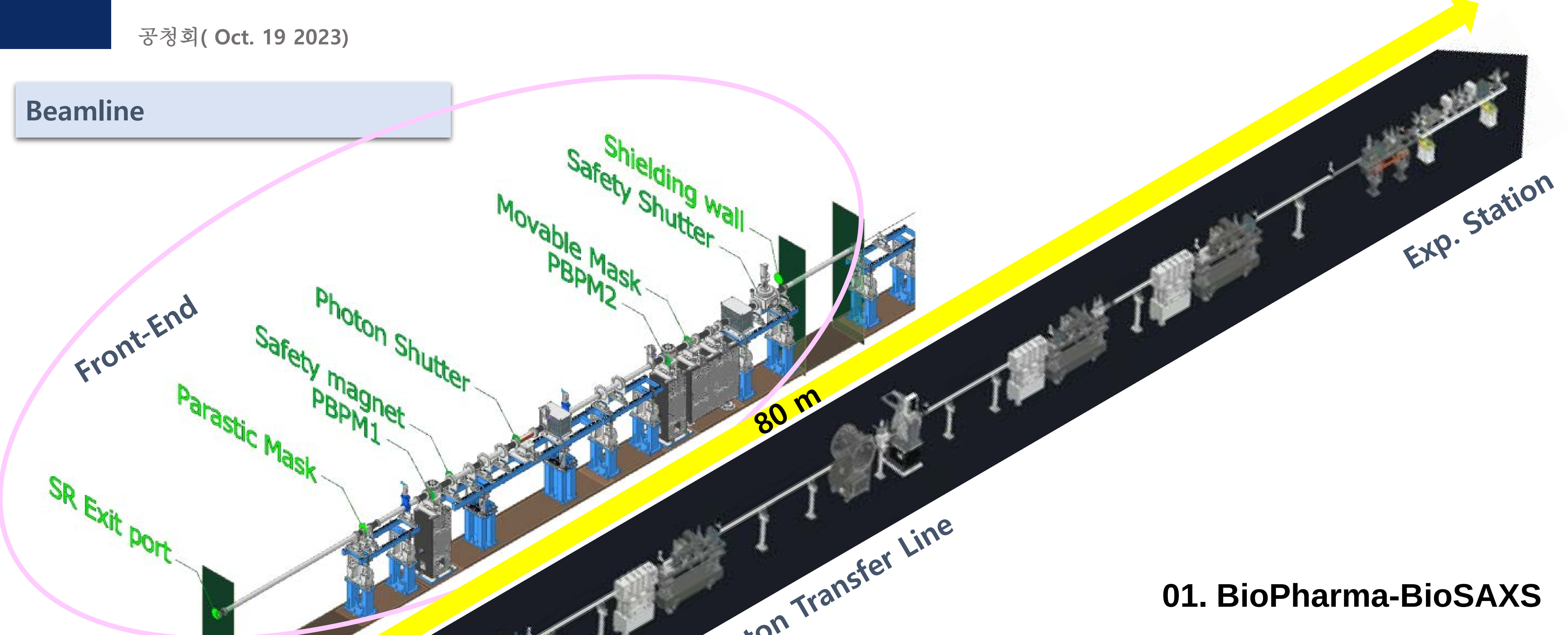


Coherence

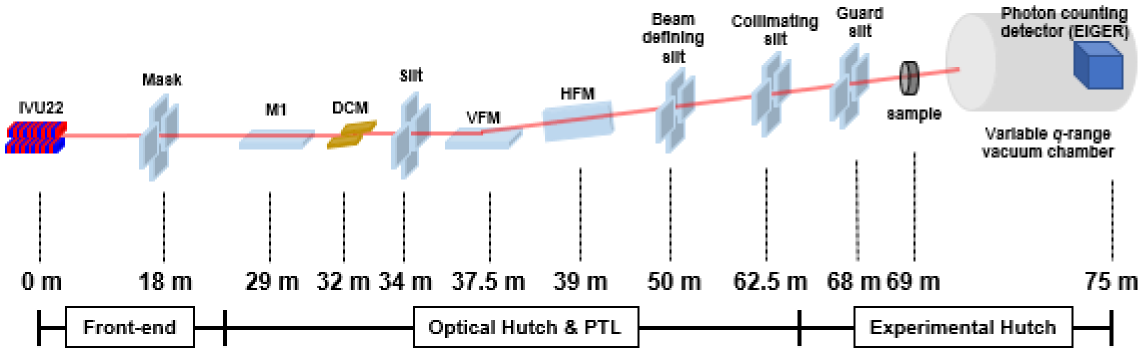


IVU20
IVU22
IVU24
Fundamental
3rd
5th
7th
9th
11th
13th
Flux (ph/s/0.1% B.W.)
Harmonic energy (keV)
10^{16}
10^{15}
10^{14}
10^{13}
10^{12}
10^{11}
10^{10}
10^{9}
0
5
10
15
20
25
30
35
40
45
50

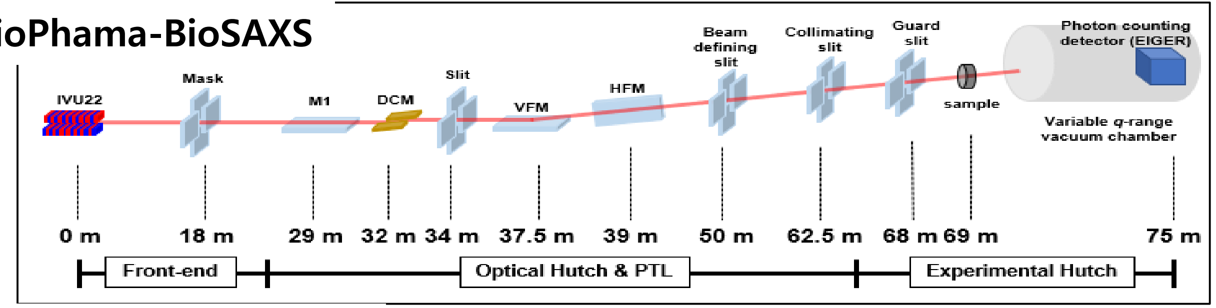
Beamline



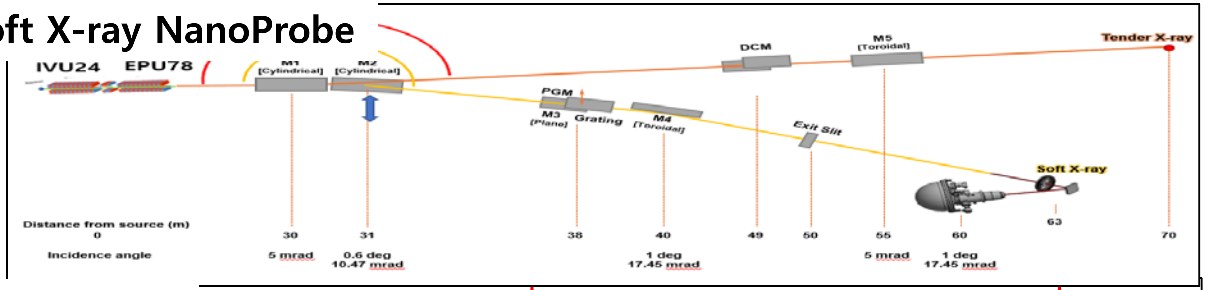
01. BioPharma-BioSAXS



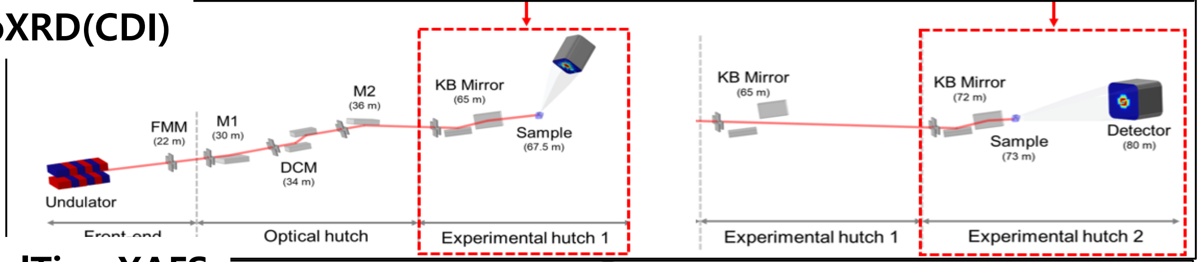
BioPhama-BioSAXS



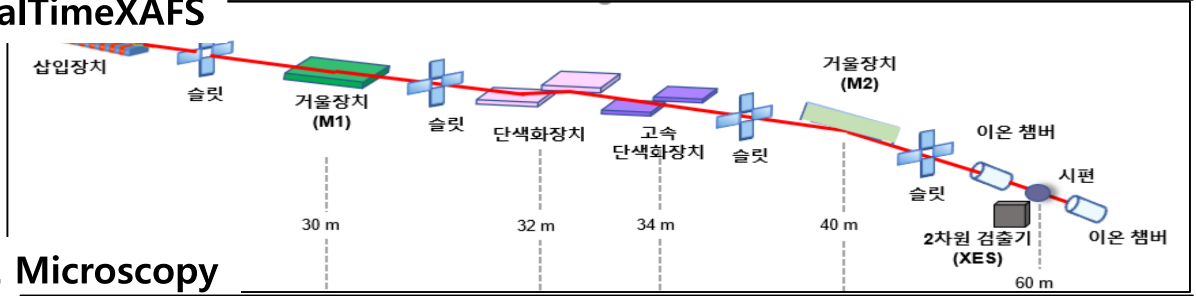
Soft X-ray NanoProbe



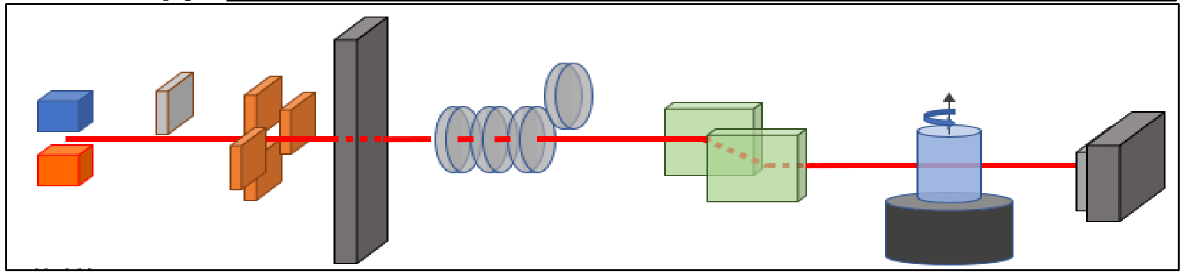
CoXRD(CDI)



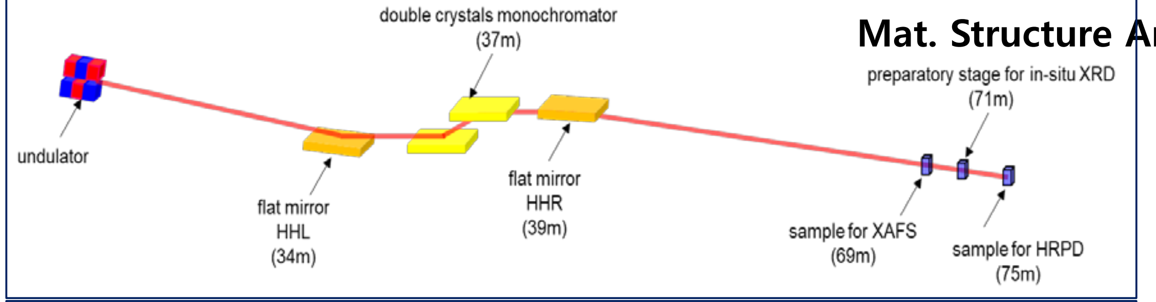
RealTimeXAFS



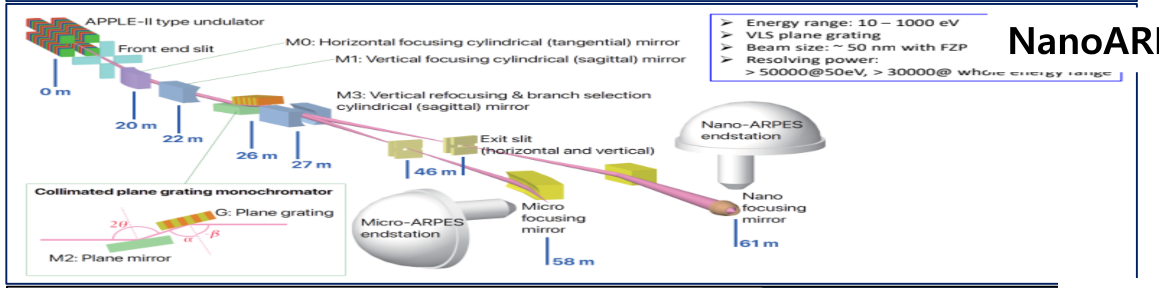
HE Microscopy



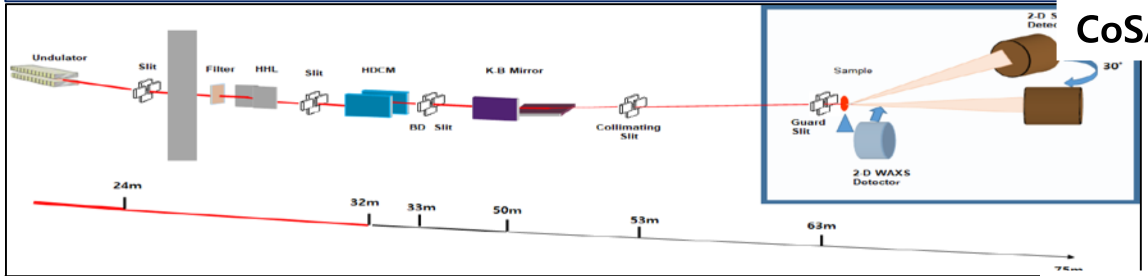
Mat. Structure Anal.



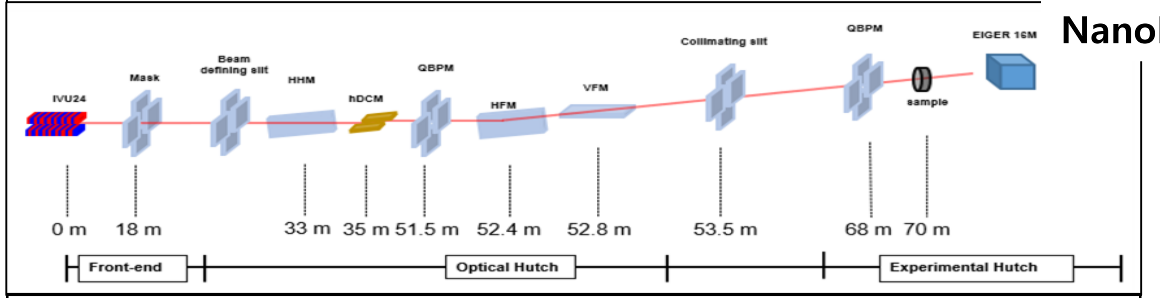
NanoARPES



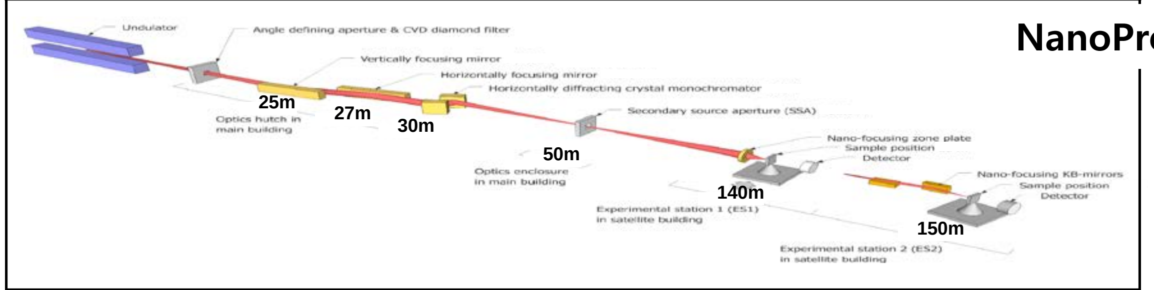
CoSAXS



NanoMX



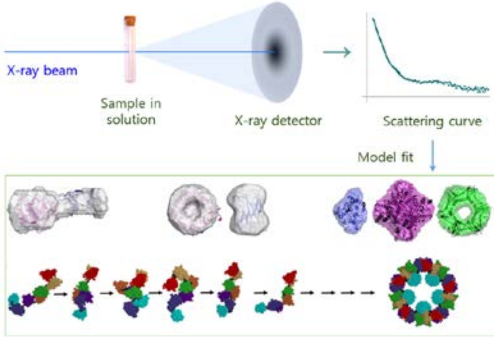
NanoProbe

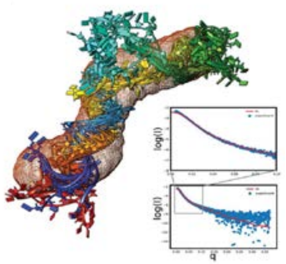


01. BioPharma-BioSAXS

❖ 3D structure of therapeutic biological molecules

- ✓ Overall structure of therapeutic molecules
- ✓ Overall status of biological molecule/drug complex
- ✓ Docking model of protein-protein complex



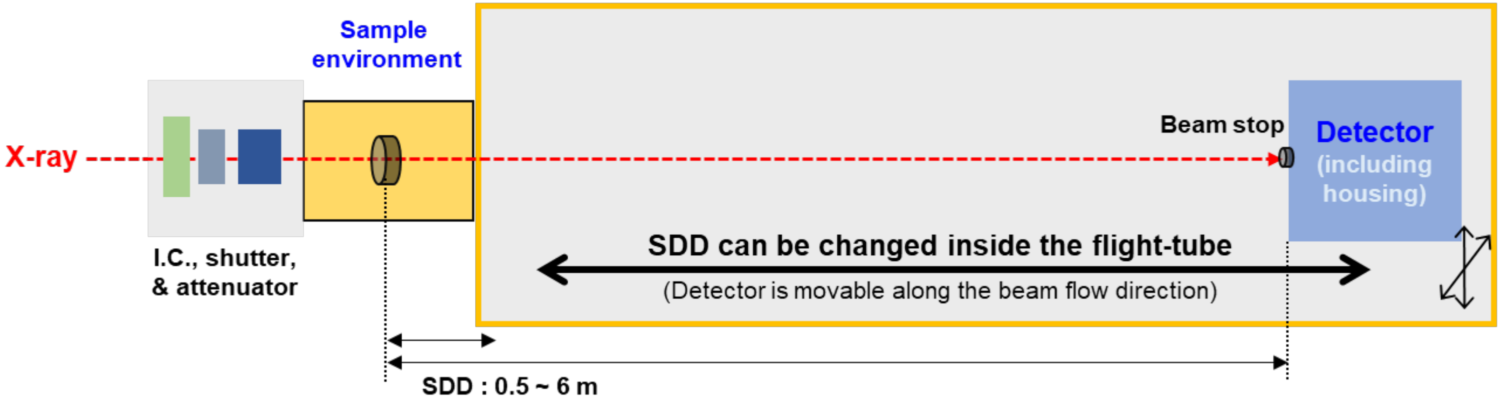


D. n. Kimet. al., Nature Comm . 2020, 11, 148

❖ Beamline Goal

구 분	내 용
Light Source	IVU22 (L=3.0 m)
Photon energy	5-20 keV (optimized at 8-25 keV)
Energy resolution	$\Delta E/E \sim 2 \times 10^{-4}$
Beam size	< 10 μm at the detector
Length scale	~ 3 - 4480 Å
Time resolution	~ 10 Hz
Beam flux	$10^{12} \sim 10^{13}$ ph/s @ 16.02 keV
Sample to Detector Distance	0.5 ~ 6 m
Techniques	(Solution) SAXS/WAXS

❖ End-station layout for high throughput Bio-SAXS technique



➢ Sample environment

✓ Automatic sample changer robot

- ARINAX, BIO-SAXS
- Minimum sample volume (5ul)
- Standard 96 well plate
- Static & flow mode
- Temperature control (4°C - 60°C)

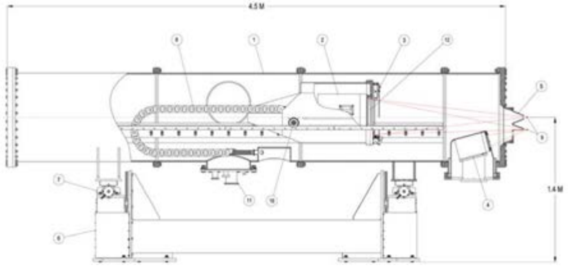
Sample Exposure Unit (SEU)
Sample Changer Unit (SCU)
Control Software
Control Electronics Rack
Fluid Management Unit (FMU)

✓ SEC-SAXS system

- Agilent infinity 1260 system, RI, UV, MALS, & DLS
- Separation and Analysis of polydisperse species or mixture

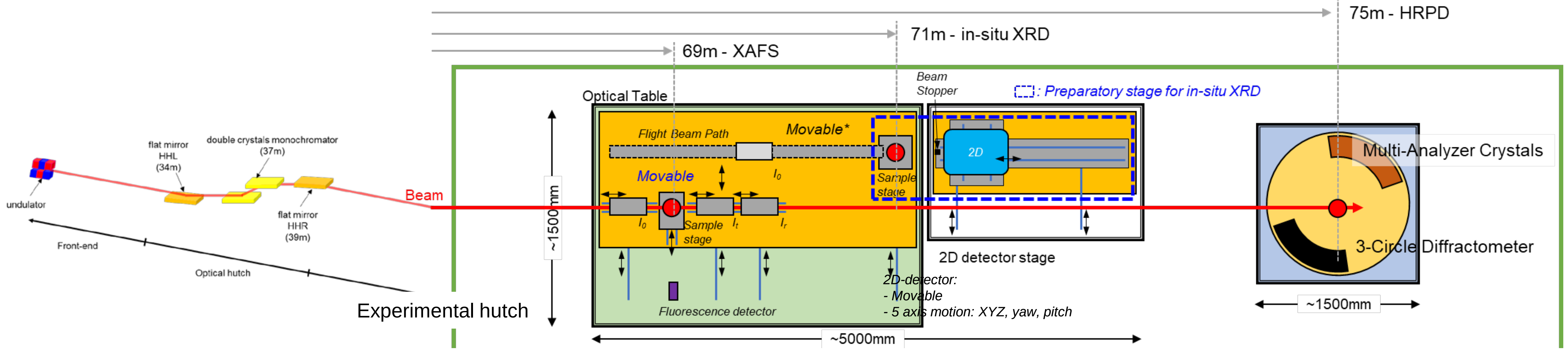
➢ Variable q-range vacuum chamber

✓ Detector is placed in the vacuum chamber to facilitate SDD change



Example; 12 ID-B, APS

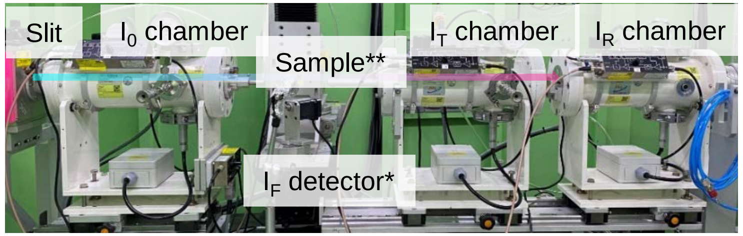
02. Material Structure Analysis



** Flight beam path and the stage for in-situ experiment (orange box) should be aligned together*

Photon Source	IVU24(L=3.0 m)
Photon energy (hv)	5 ~ 40 keV [Main : 20 keV for HRPD]
Energy resolution (ΔE/E)	~ 1.3 x 10^{-4} (Si (111) ~ 2.7 ×10^{-5} (Si (311)
Beam size (FWHM)	~ 600 (h) × 230 (v) μm^2 @sample (69m for XAFS) ~ 670 (h) × 230 (v) μm^2 @sample (75m for HRPD)
Beam flux	~ 1 ×10^{13} ph/s @sample
Techniques	XAFS: Step scan mode HRPD: Multi-analyzer detector system

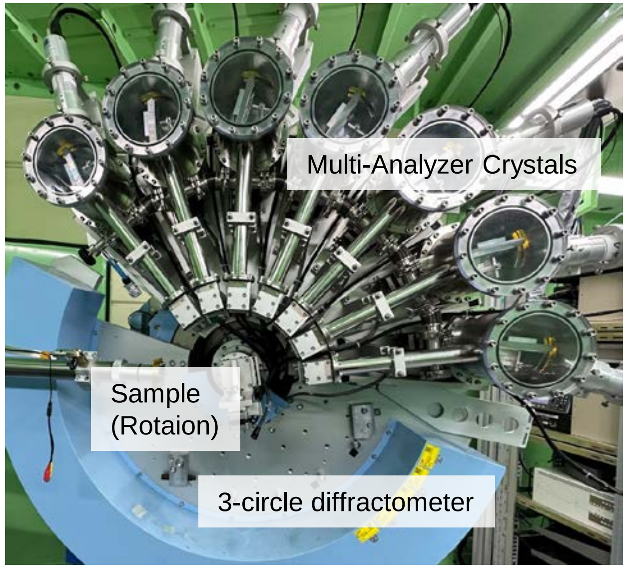
➢ X-ray Absorption Fine Structure (XAFS)



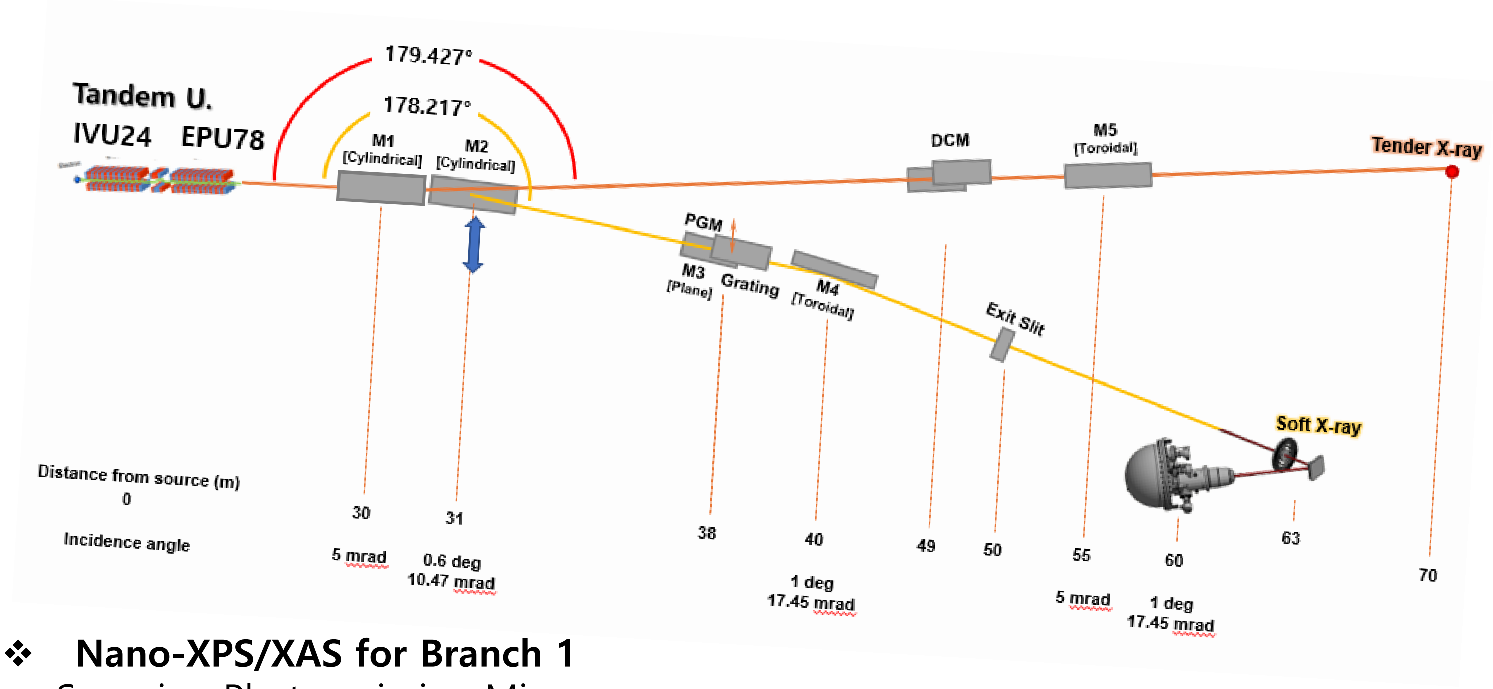
Gas auto-exchange system required
** Fluorescence detector*
*** Hexapod sample stage*

Multi sample holder
Sample stage to configure various experiments

➢ High-Resolution Powder Diffraction (HRPD)



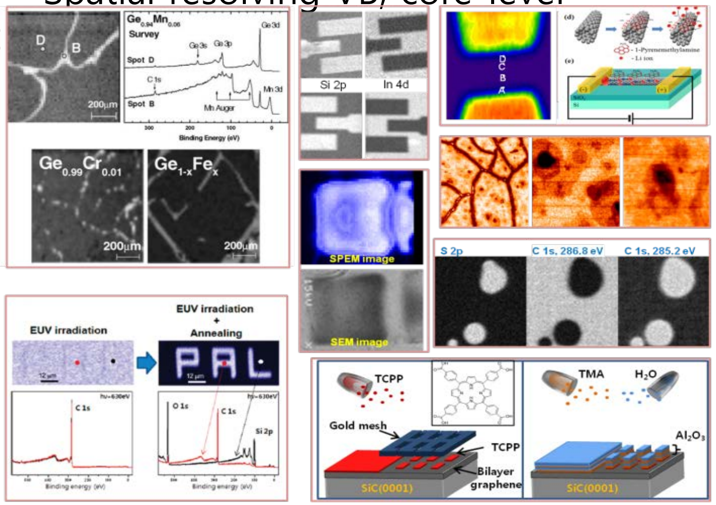
03. Soft X-ray Nano-probe

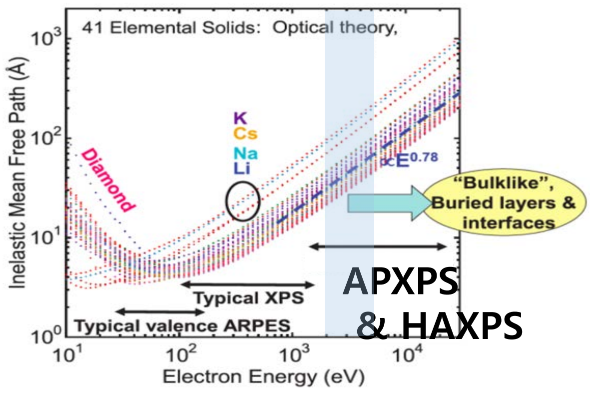


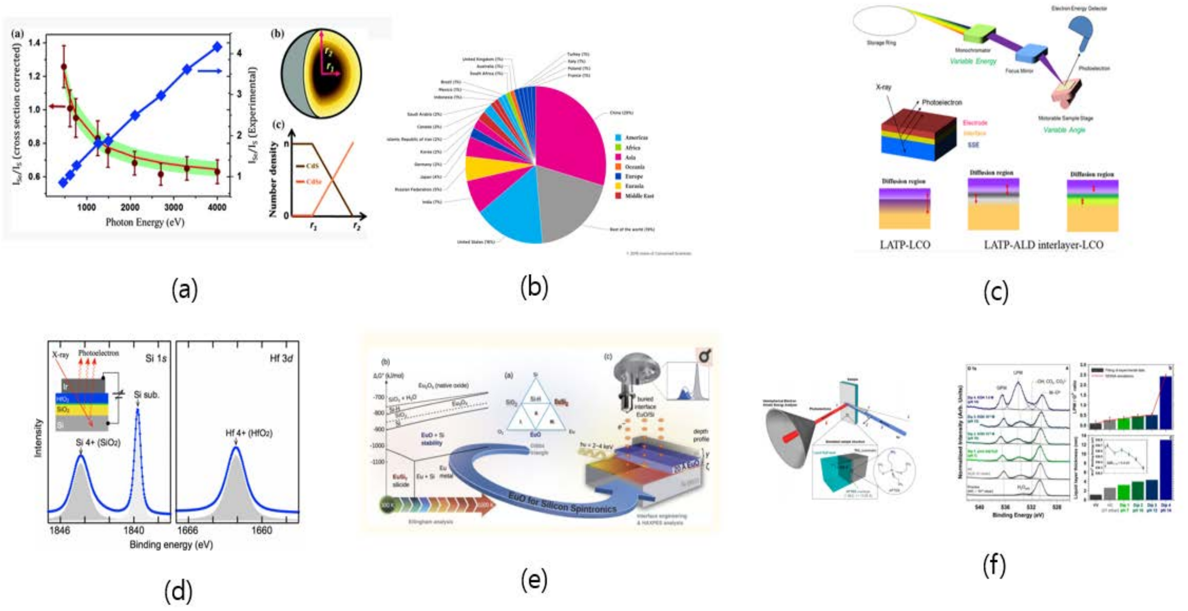
	EPU78(L=2 m)	IVU24(L=1.5 m)
E_{1st}	77.45 ~114.73 eV	1336.4 eV
Energy range	90 – 3,200 eV	2000 ~ 5000 eV
Beam size at Sample	70 nm × 140 nm by FZP	10.8 μm x 8.4 μm
Brilliance [photons.s −1 mrad -1 . mm -2 (0.1%B.W)]	1.18 × 10^{19} at 15 mm gap	1.11925 × 10^{21} at 5 mm gap

❖ **Nano-XPS/XAS for Branch 1**
- Scanning Photoemission Microscopy
- Dynamic beam size incl. zone-plate focusing
- Spatial resolving VB, core-level
p

❖ **Tender XPS/XAS for Branch 2**
- Tender X-ray Phtoemission Spectroscopy & XAS
- Non-destructive bulk property probe.



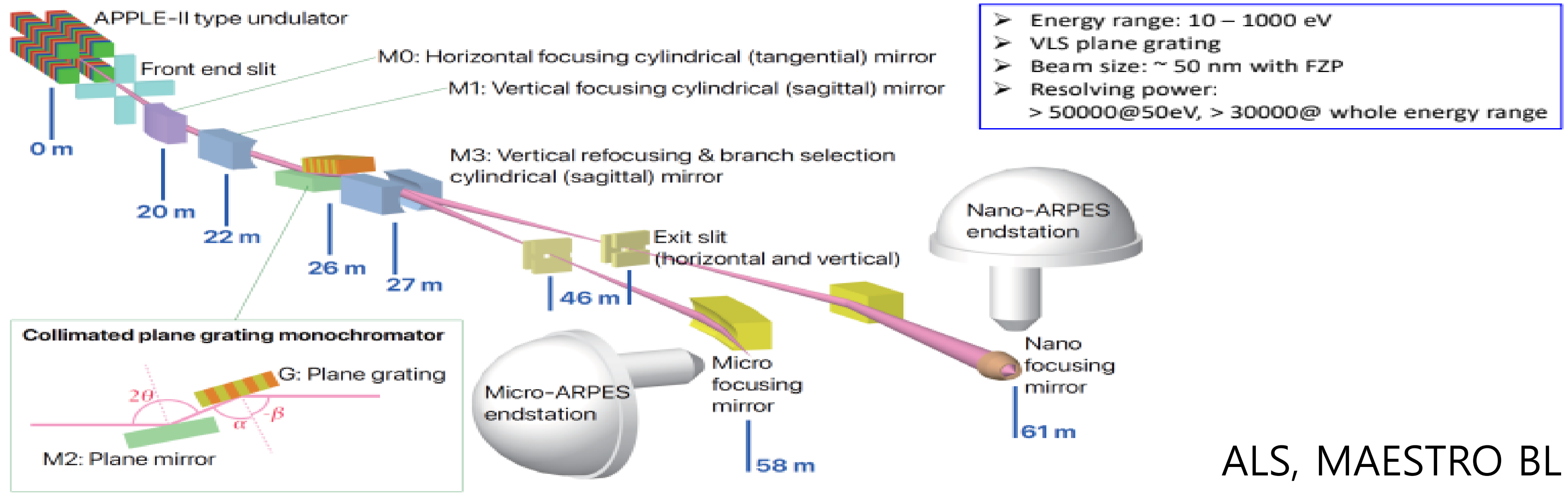




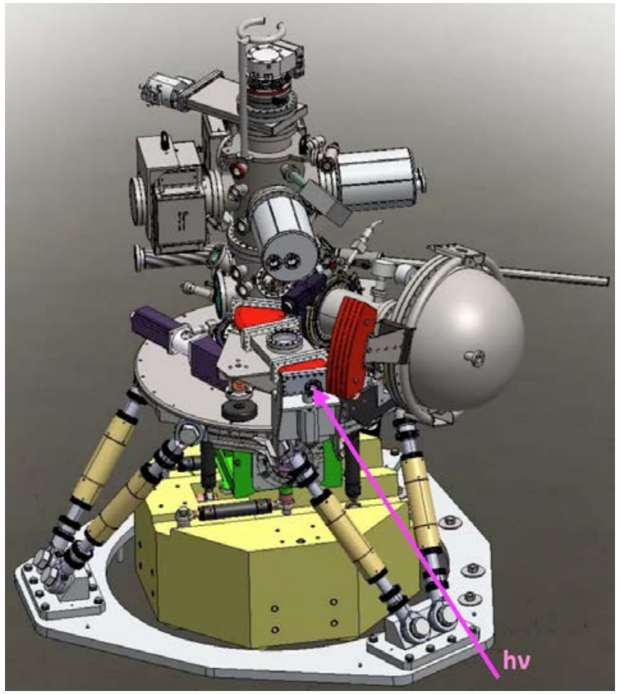
04. Nanoscale Angle-resolved Photoemission Spectroscopy(NanoARPES)

Light Source	EPU98(L=3.6 m)
Photon energy(hv)	0.1 – 2 keV [Optimize: 50 ~200 eV]
Energy resolution (ΔE/E)	20,000
Beam size	100 x100 nm^2 by FZP
Beam flux	▪ 10^{12} - 10^{13} ph/s @ 90eV ~ 2,000eV ▪ 10^{10} - 10^{12} ph/s @ 2,000eV ~ 3,200eV

End-stations	nano-ARPES	- nano-focusing optics: Zone plate @ Capillary mirror - Hemisphere electron analyzer - Photon energy range: 100-200 eV - Energy Resolution: < 10 meV @ 100eV - Photon flux: ~ 10^{11} phs with ZP @ 100eV
	μ-ARPES	- micro-focusing optics: K-B Mirrors or Capillary Mirror - Hemisphere electron analyzer with spin detectors - Photon energy range: 100 – 2000 eV - Energy Resolution: < 5meV @ 100 eV - Photon flux: > 10^{12} phs @ 100eV



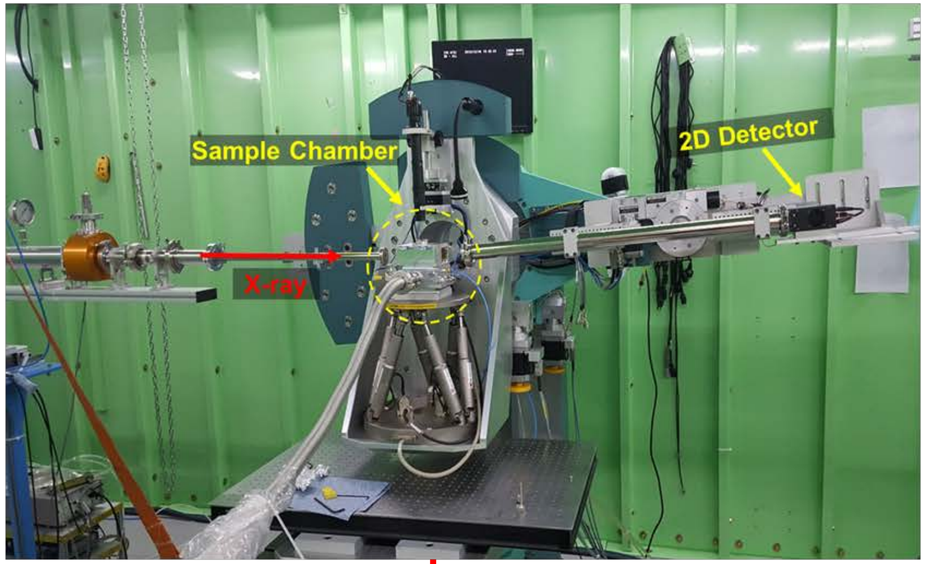
ALS, MAESTRO BL



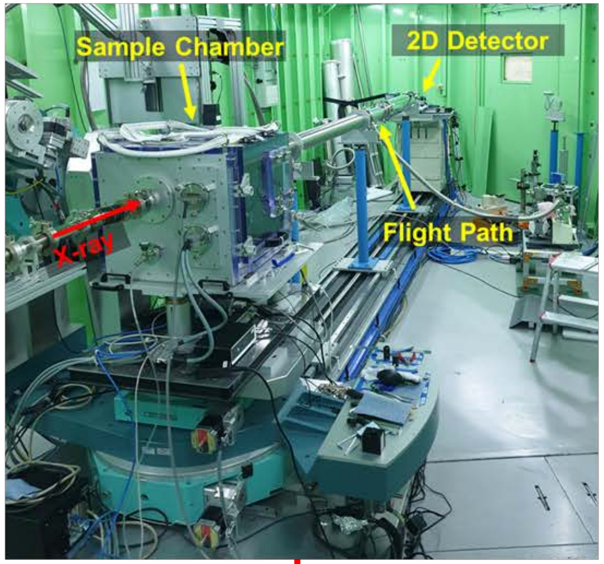
05. Coherent X-ray Diffraction(CXD)

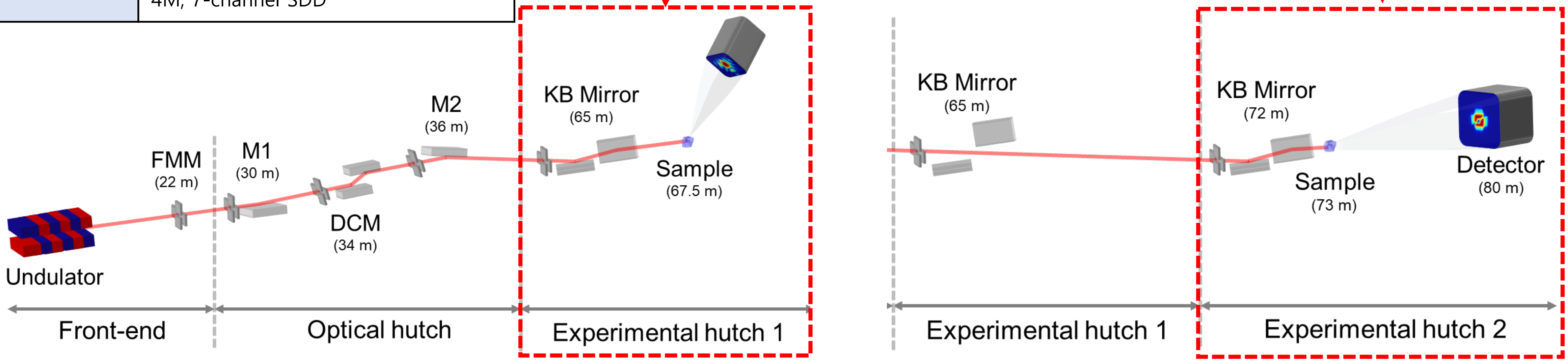
Light Source	IVU24(L=3.0m)
Photon energy	3 – 30 keV
Energy resolution(ΔE/E)	< 2 x 10^{-4}
Beam size	< 500 nm ~ few micron at the sample
Beam flux	~10^{13}ph/s at the sample
Techniques	CDI, (time-resolved) Nanobeam X-ray Diffraction
Experimental hutch instrument	EH1) 6-circle diffractometer(Kappa)
	EH2) CDI chamber, Flight path
Detector	Lambda 250k, Eiger2 X 1M, Eiger2 X 4M, 7-channel SDD

< BCDI, Bragg ptychography, Nanobeam X-ray Diffraction >



< Transmission Ptychography >

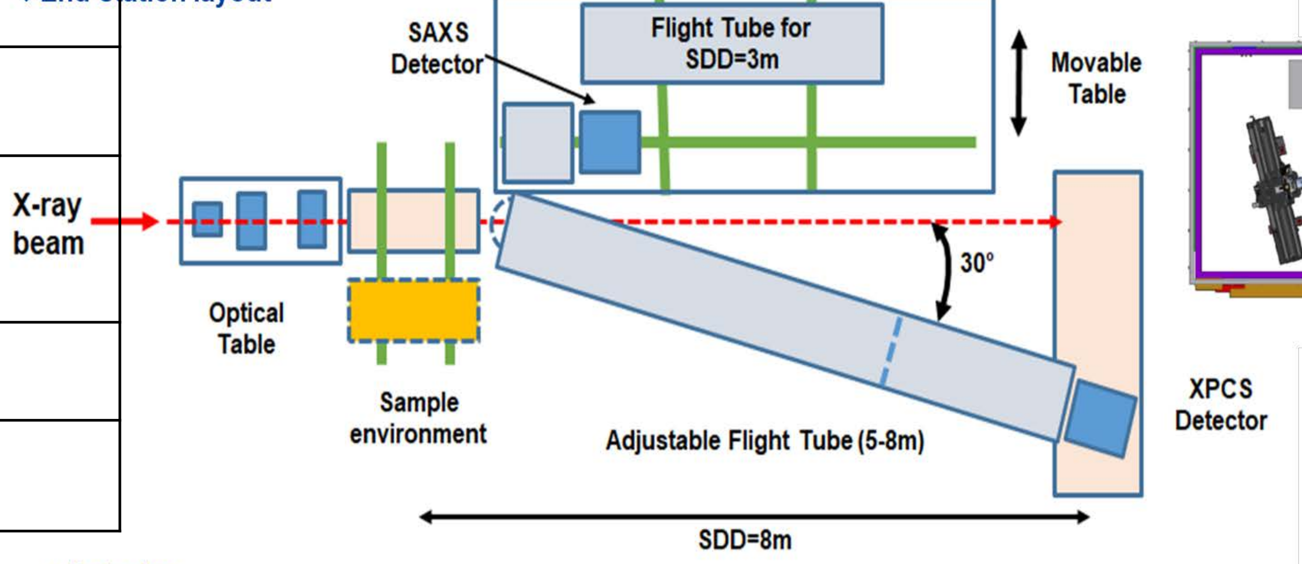


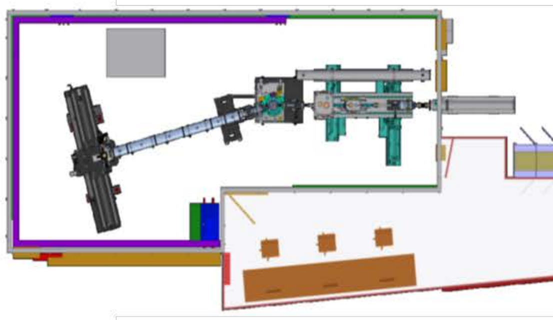


06. Coherent Small-angle X-ray Scattering

Light Source	IVU20(L=3.0m) Brilliance:~$2x10^{15}$phs/s/0.1%BW, Coherence fraction : 0.05 x0.22
Photon energy(hv)	4 – 40 keV → **7 – 30 keV**
Energy resolution(ΔE/E)	**~ 1 x 10^{-4}(Si (111)** ~ $3x10^{-05}$(Si(311))
Beam size	<10 μm @ 2Ddetector (~ 1 μm @ sample for μSAXS/WAXS)
Beam flux	~10^{13}phs/s @ sample
Techniques	μ(GI)SAXS/WAXS XPCS

❖ **End-station layout**





Example: PETRAIII P10 beamline.

❖ **Detector**

	Eiger2 X 4M (Dectris, SAXS)	Eiger2 X 4M (Dectris, XPCS)
Dimension	155.1 X 162.15 mm^2	155.1 X 162.15 mm^2
Pixel size	75 X 75 um^2	75 X 75 um^2
Dynamic range	~ 10^7 photons/pixel/s	~ 10^7 photons/pixel/s
Readout rate	Up to 1120 Hz	Up to 1120 Hz

- X, Y, Z direction and Tilt around Y

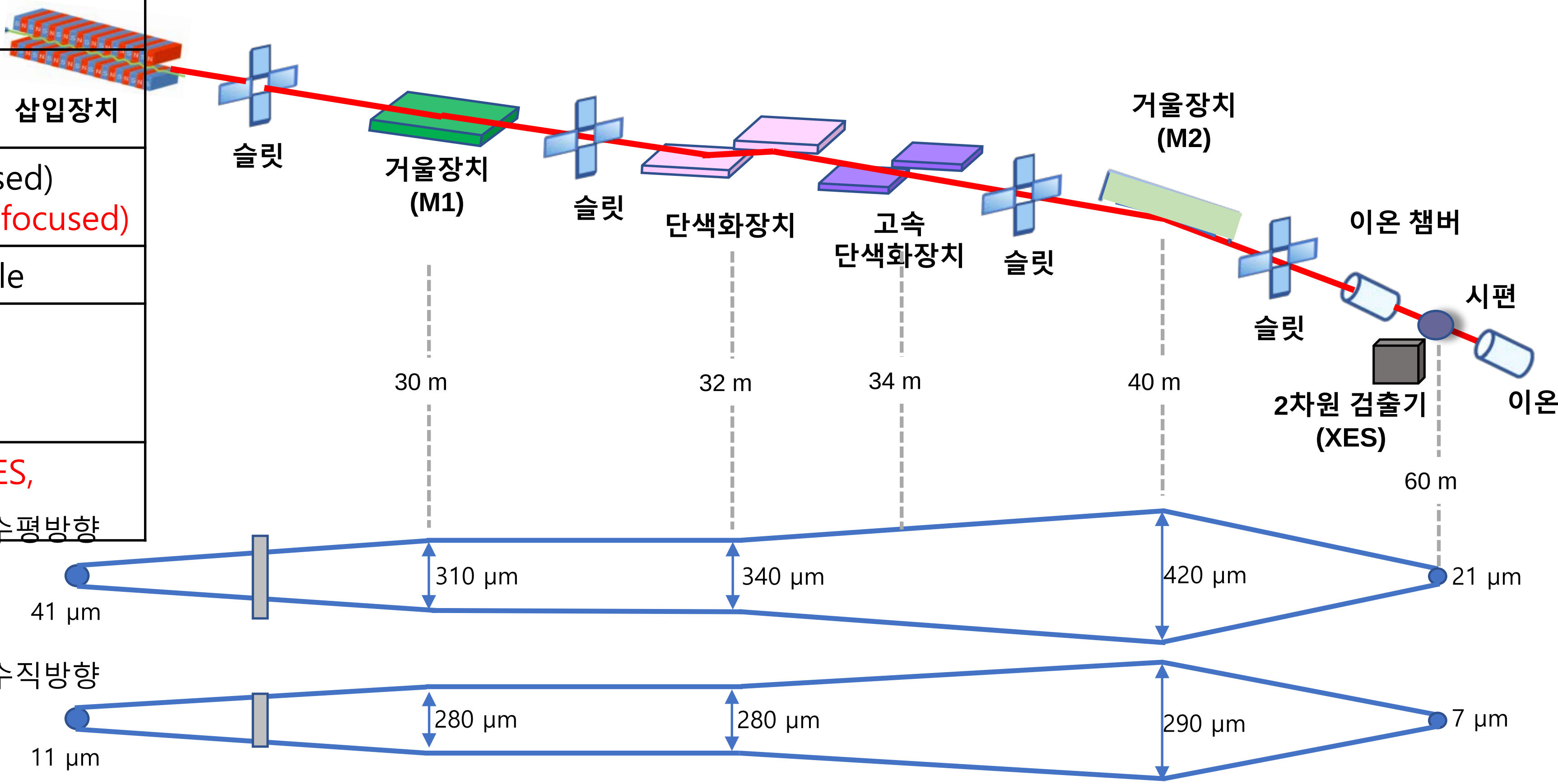
❖ **q- range & correlation time**

- **Max. q : 2.5 Å-1 at SDD=25cm**
- **Min. q : 0.001 Å-1(471nm) at SDD=8m**
- **Horizontal detector movement for XPCS : 2θ= 0~30°**
- **Time scale: a few μsec ~ hundreds of second**
- **Coherence length @ sample** : ~ 0.02 mm x 0.09 mm

07. Real-time X-ray Absorption Fine Structure

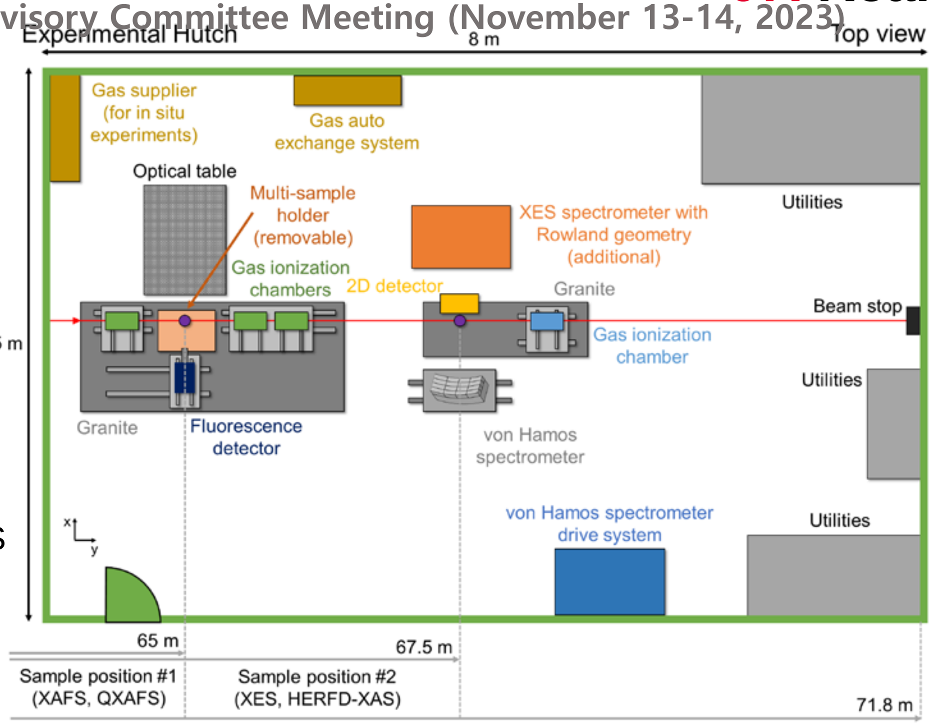
❖ Beamline Goal

Light Source	IVU24 (L=3.0m)
Photon energy(hv)	4 – 40 keV
Energy resolution(ΔE/E)	**~ 5 x 10^{-4} (Si (111))** < 0.5 eV for XES
Beam size (at sample, FWHM)	~ 30 x 10 μm^2 (focused) ~ 800 x 300 μm^2 (unfocused)
Beam flux	~10^{13} phs/s @ sample
Time scale	Step scan ~ 20 min On-the-fly~ 3 min Quick scan ~ 10 ms
Techniques	XAFS, Quick-XAFS, XES, HERFD-XANES



07. Real-time X-ray Absorption Fine Structure

❖ End-station layout



- Main experiment

Absorption spectroscopy: XAFS, QXAFS

Emission spectroscopy: XES, HERFD-XAS

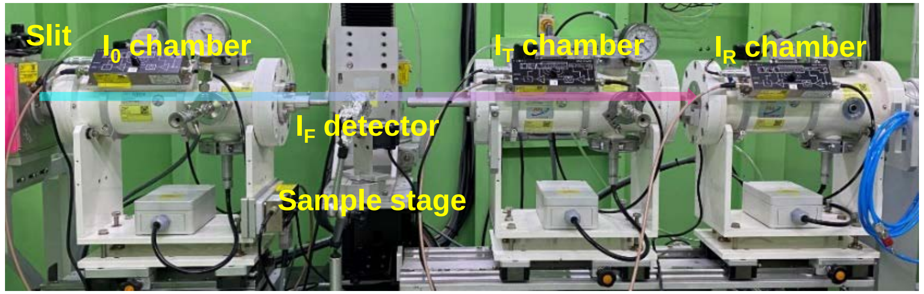
- Design goal

Wide energy range: 4 ~ 40 keV

High photon flux: ~ 10^{14} ph s^{-1}

Small beam size: ~ 21 (H) x 7 (V) μm^2

❖ XAFS & QXAFS

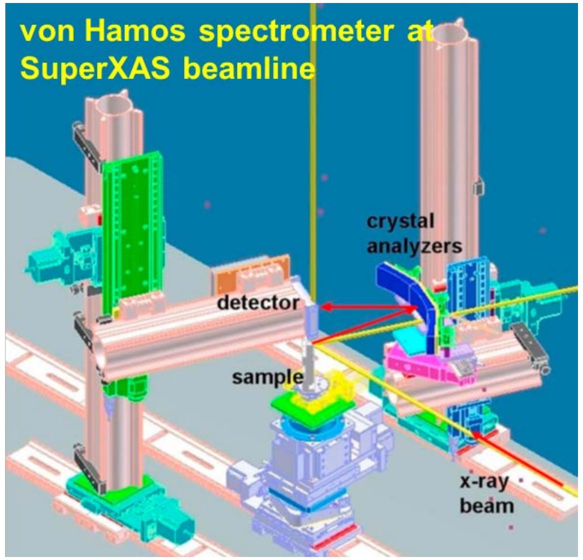


- Grided gas ionization chamber

- Fluorescence detector

- Multi-sample holder & Hexapod stage

❖ XES & HERFD-XAS



- Multi-crystal von Hamos spectrometer

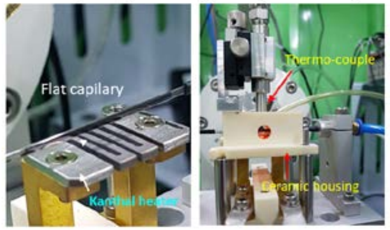
→ Si(200), Si(200), Si(220)
Ge(111), Ge(200), Ge(220)

- 2D detector

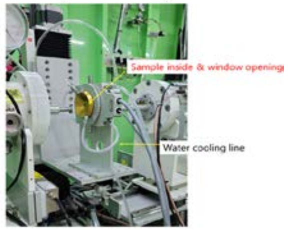
Detector	LAMBDA (X-Spectrum)
Dimension	85 x 28 mm^2 (750k) 170 x 170 mm^2 (2M)
Pixel size	55 x 55 μm^2
Count rate (ph/s/mm^2)	~3 x 10^8
Readout rate	1 kHz - 24 kHz

❖ Equipment for In-situ measurement (examples)

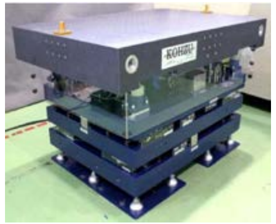
Flat capillary heating cell (~ 400 ˚C)



Linkam heating cell (~ 1000 ˚C)

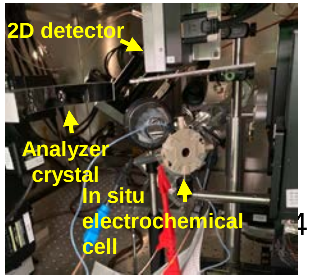


- Optical table



In-situ electrochemical cells & Potentio-/Galvanostat

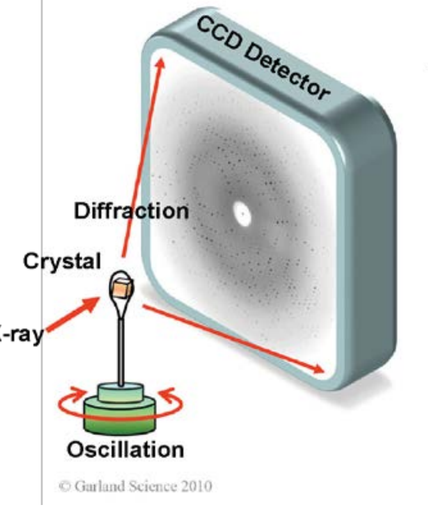
- In situ XAFS & XES

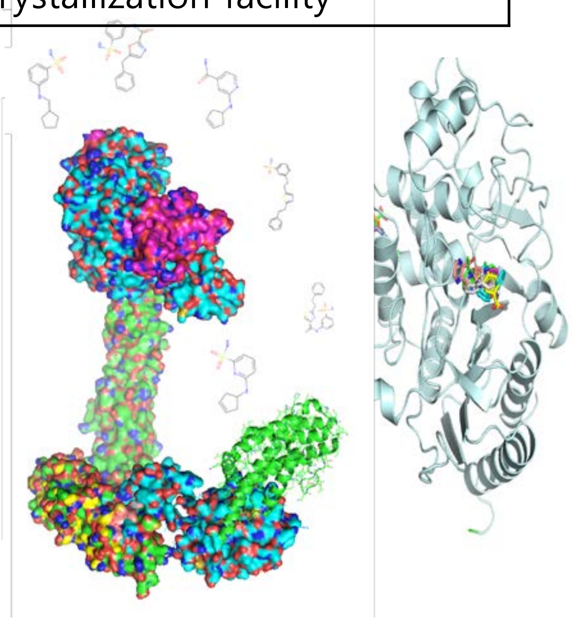


08. Bio Nano crystallography (BioNX)

❖ Beamline goals

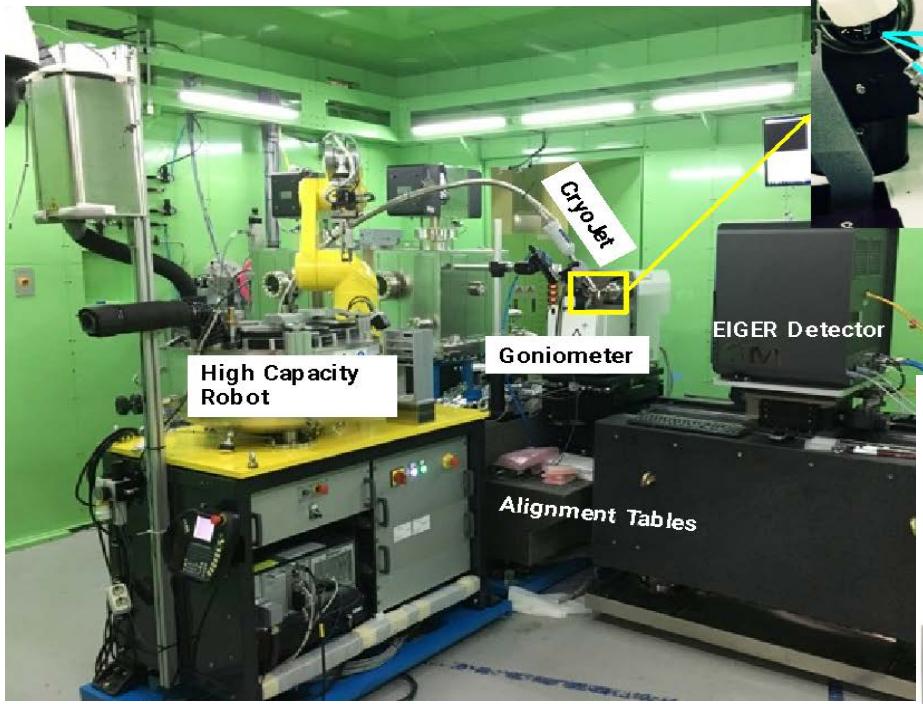
Light Source	IVU20(L=3.0m)
Photon energy(hv)	5 ~ 20 keV [Optimize :6.5 ~ 20 keV]
Energy resolution (ΔE/E)	~ 1 x 10^{-4}(Si (111)
Beam size	~16 (h) ×4 (v) μm^2 at sample
Beam flux	~10^{13} ~ 10^{14} phs/s @ sample
Techniques	Experimental Hutch : X-ray crystallography Wet Laboratory: crystallization facility





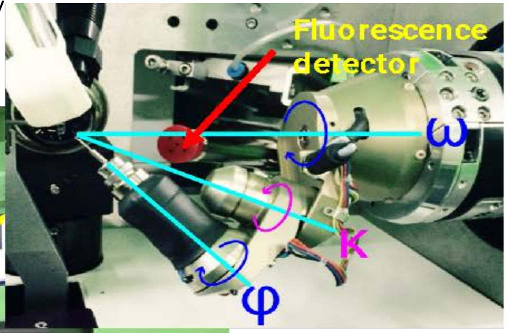
❖ Biomacromolecule crystal structure

- ✓ High resolution (~1 Å)
- ✓ Understanding life science at the molecular level
- ✓ Chemical drug design support
- ✓ Antibody Drug study support



❖ Structure-based drug design

- ✓ High-throughput structure analysis
- ✓ Identification Fragment Definition
- ✓ Accelerated Sculpture Design
- ✓ 500 data/day



Multi-axis goniometer

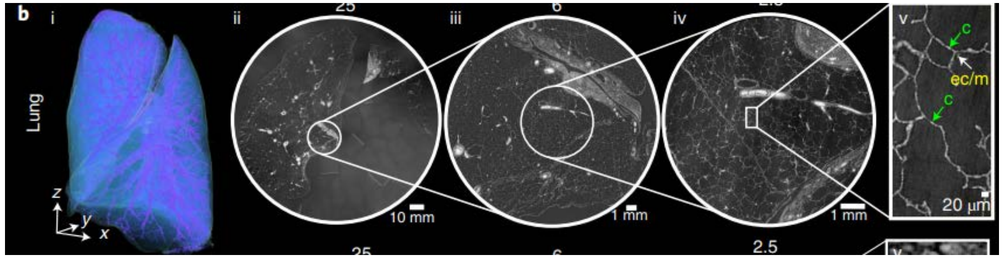
MD3 로봇 장치

09. High Energy Microscopy (HEM)

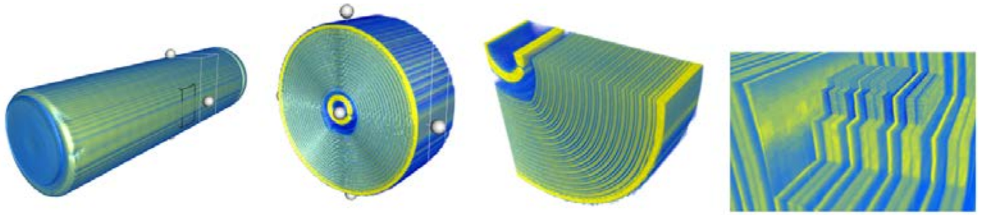
Design goals

Imaging spatial resolution	a few μm (1 μm)
Photon energy	10-130 keV
Beam size	200 mm
CT scan taking time	Minutes
Phase contrast effect (Refraction detection limit)	< 0.1 μrad
Sample position	100 m
In-situ/operando sample space	a few m
Max sample weight	300 kg

Multiscale Imaging



Walsh, C. L., et al. (2021). *Nature methods*, *18*(12), 1532-1541. Images taken at BM05, a predecessor beamline, at 60-80 keV

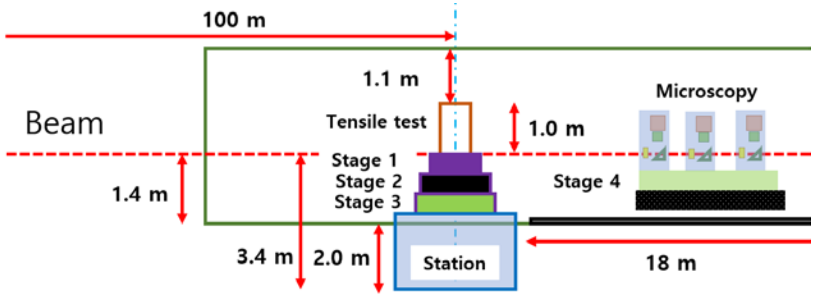


(a) Overview (b) Intermediate region (c) Final region (d) Composite rendering

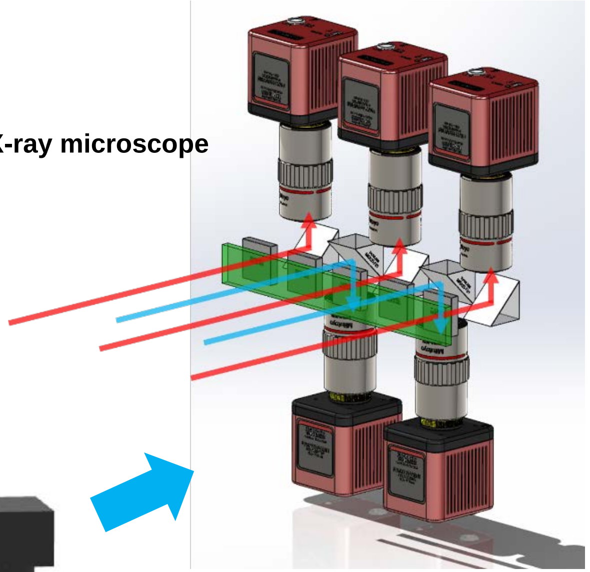
Lang et al. (2023), e-Journal of Nondestructive Testing 28(3). Multiscale Phase-Contrast Tomography at BM18

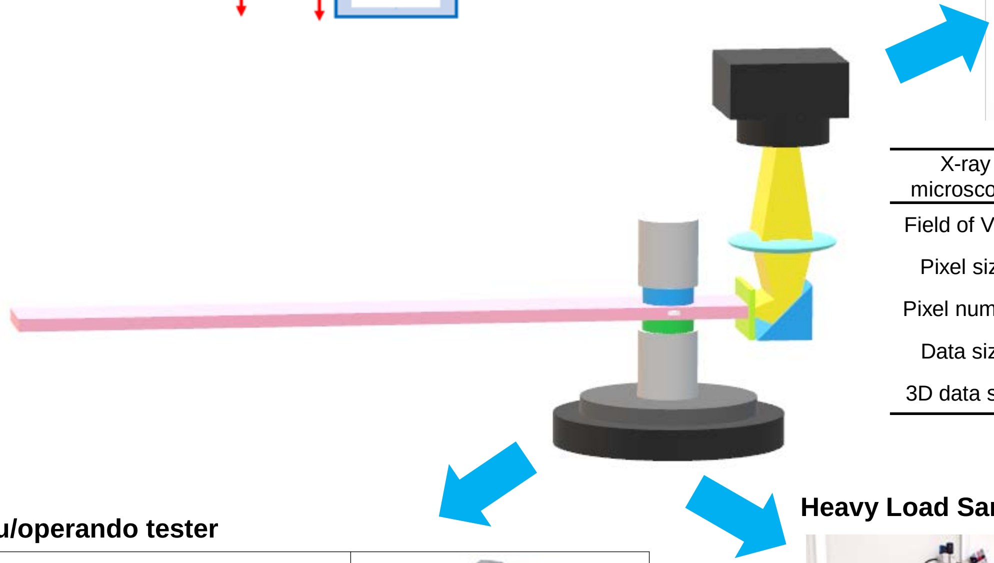
Experimental Equipment

Experimental hutch design



High aspect ratio X-ray microscope





X-ray microscope	High aspect ratio	High resolution
Field of View	200 x 25 mm^2	1.3 x 1.3 mm^2
Pixel size	5 μm	0.25 μm
Pixel number	200 million	25 million
Data size	400 MByte/img	50 MByte/img
3D data size	16 TByte/set	1 TByte/set

In-situ/operando tester

Dimension (LxWxH)
: 820 mm x 630 mm x 180 mm

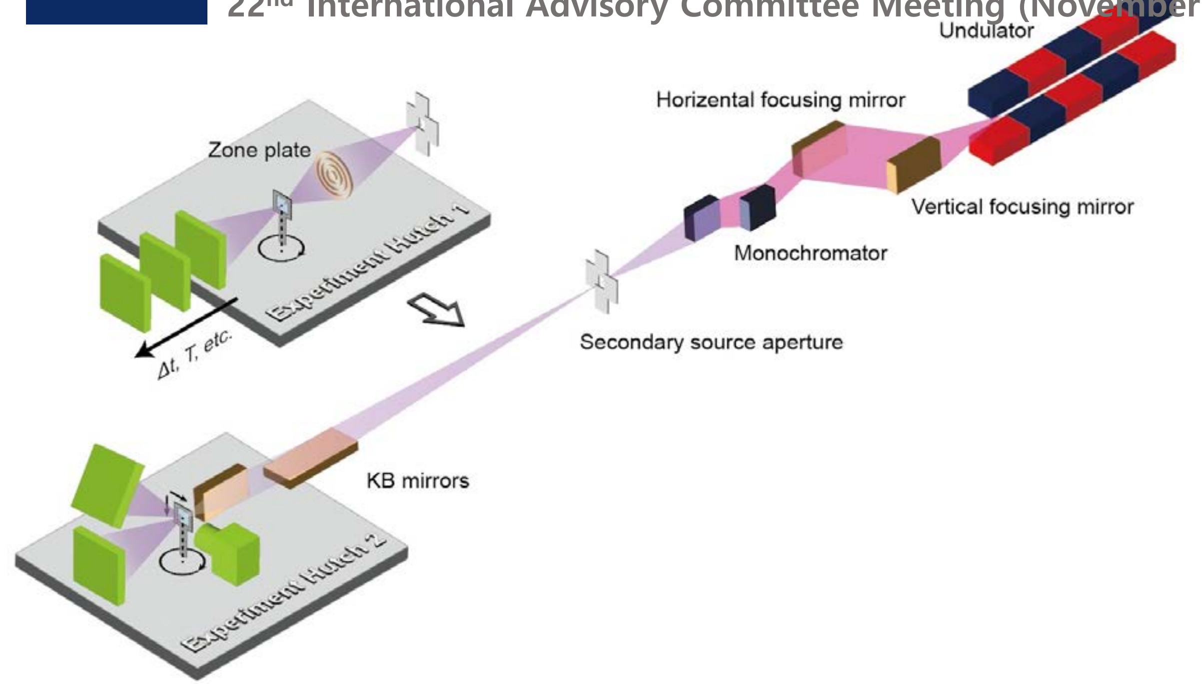
Weight
: 216 kg

Max. Capacity
: 10 kN

Stroke Space
: 1400 mm

Heavy Load Sample Station

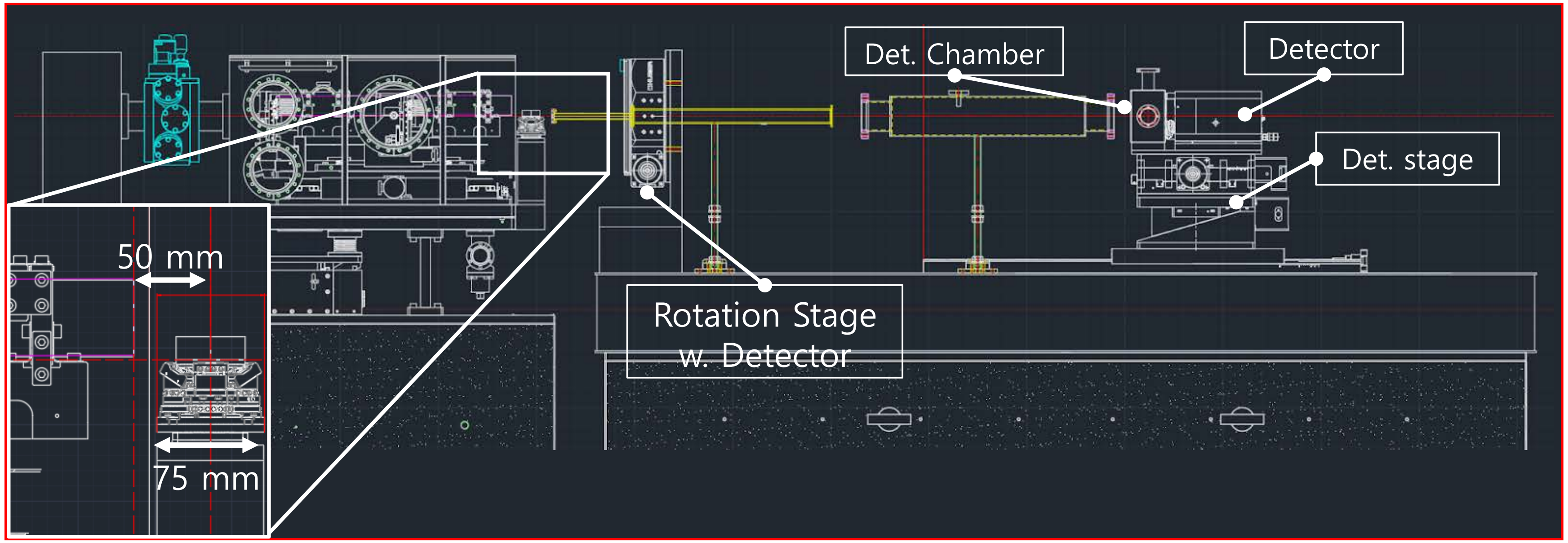
10. Nano-probe beamline

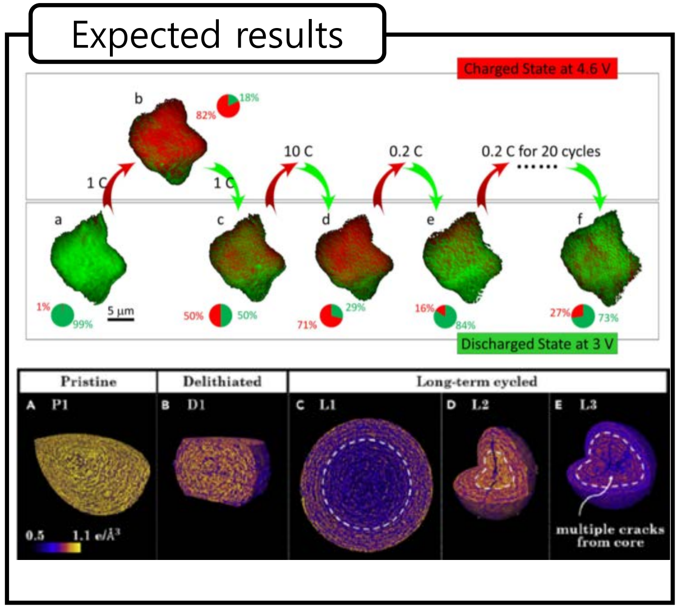


❖ Beamline Goal

	Nano-Coherent imaging	Nano-Scanning microscopy
Energy	5-25 keV	
Beam size	~ 100 nm	~ 50 nm
Exp.	In-situ Coherent imaging	Ptychography Nano-XRF Multimodal imaging
Resolution	< 50 nm (XRF), < 5 nm (Imaging)	
Photon flux	10^9 -10^{11} phs/s @ Sample	

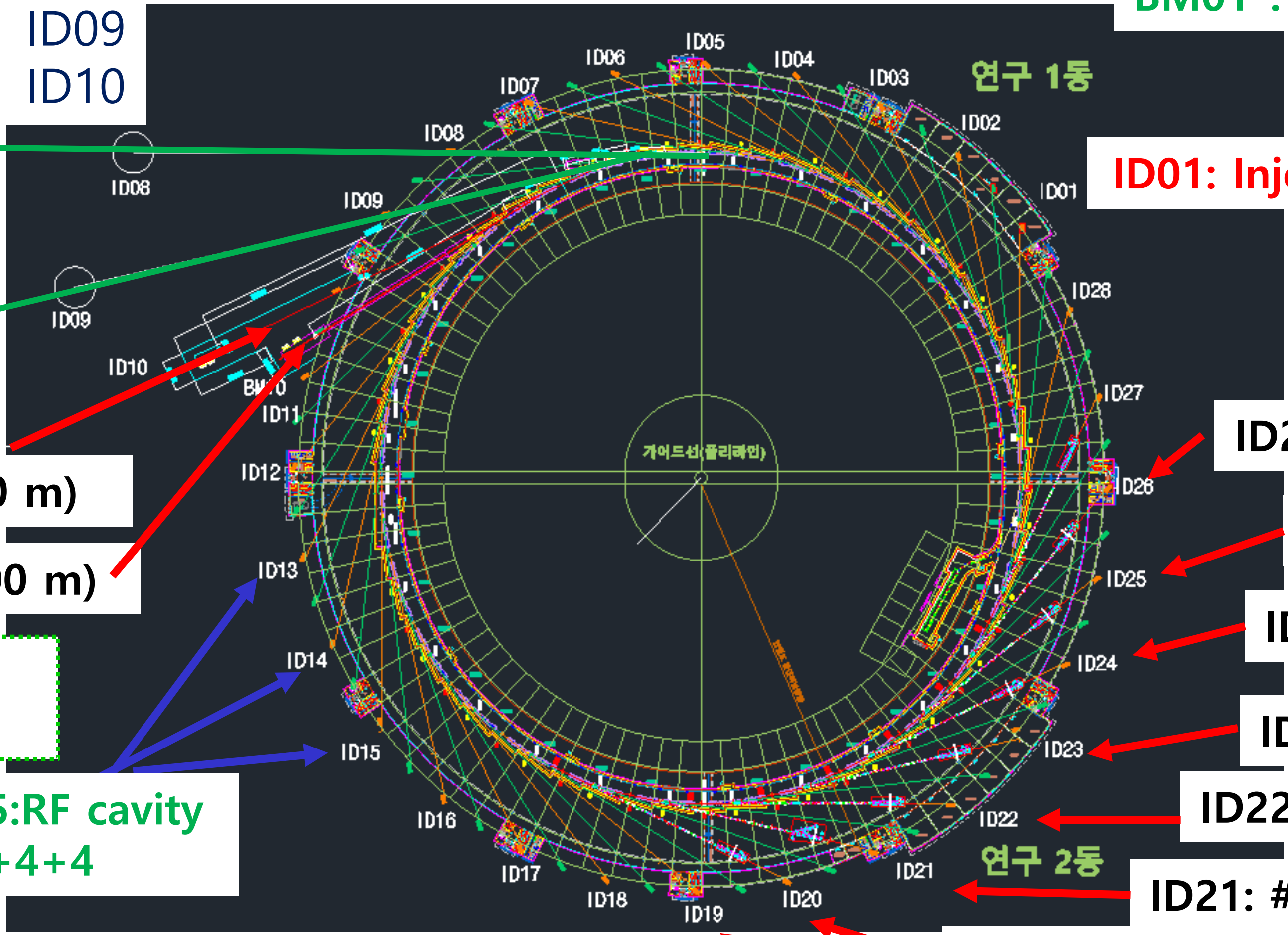
❖ Design of endstation





Xu, Yahong, et al. *ACS Energy Letters* 2.5 (2017): 1240-1245.
Tsai, Esther HR, et al. *IScience* 11 (2019): 356-365.

❖ Beamline Floor Plan
(Oct. 30 2023) Present



ID08
ID09
ID10

BM15: Diagnostic BL
BM01*: Diagnostic BL

ID01: Injection

ID26: #03 Soft X-ray NanoProbe
ID25: #04 NanoARPES
ID24: #02 Material Structure
ID23: #07 RealtimeXAFS
ID22: #08 BioNX.
ID21: #01 BioPharma-BioSAXS
ID20: #06 CoSAXS
ID19: #05 CoXRD(CDI)

ID10: #10 NanoProbe(150 m)
BM10: #09 HE Microscopy(100 m)

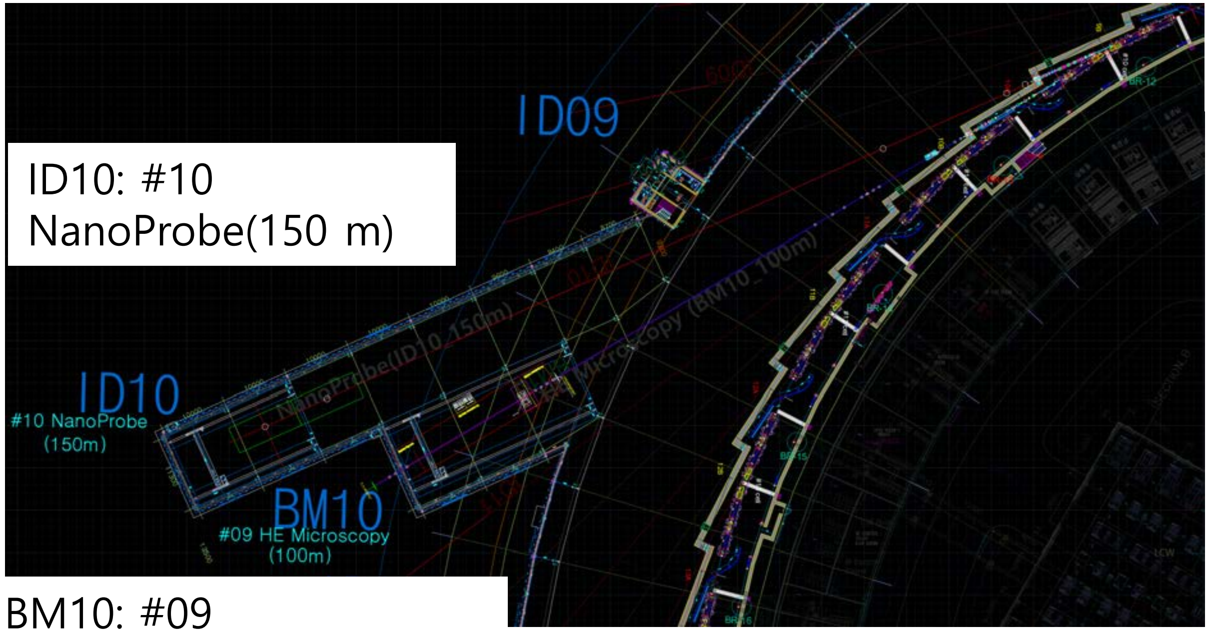
ID11,12,16:
Harm. Cavity 2+2+2

ID13,14,15:RF cavity
2(2)+4+4

❖ Long BL
- 09. HE Microscopy BL(L=100 m)
- 10. NanoPrpbe BL(L=150 m)

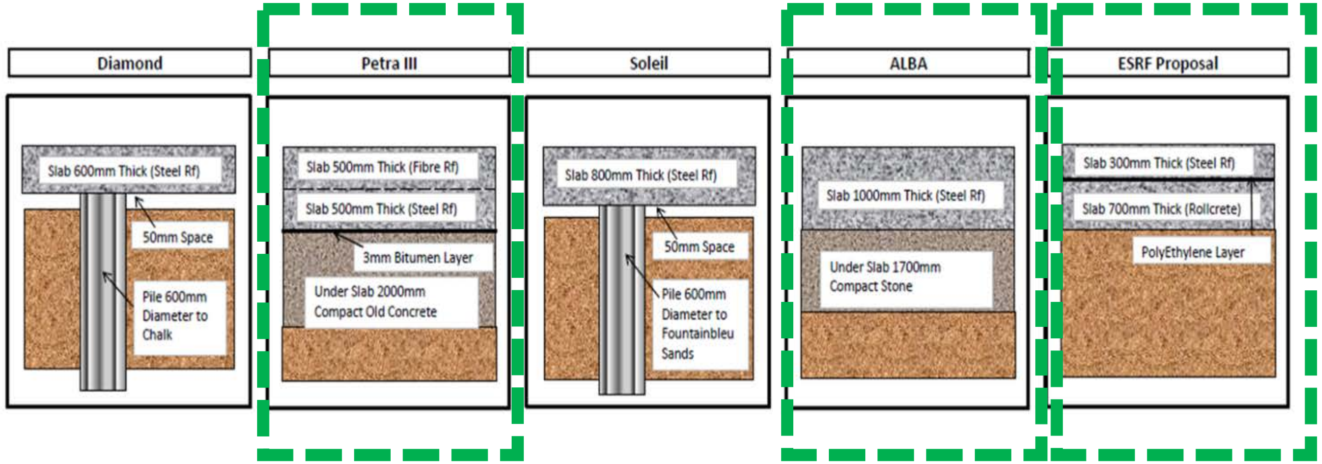
➢ Key point
- Vibration
- Radiation Safety
- Thermal stability

ID10: #10
NanoProbe(150 m)



BM10: #09
HE microscope(100 m)

➢ Slab for Vibration Damping
- I m Slab structure
- Similar to Petra-III, ALBA, ESRF-EBS.



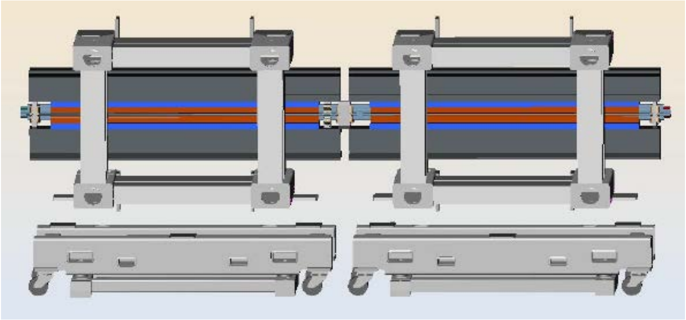
➢ Radiation Safety : PTL and Exp. Hutch Concrete
- HE Micriscopy : 5 ~ 100 keV
- NanoProbe : 5 ~ 25 keV

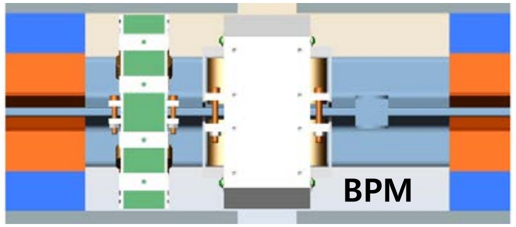
➢ House in house hutch structure

Canted BL Available (for Phase-II)

- **1 mrad canted study for 4GSR**
  → Apply to design

Undulator Configuration



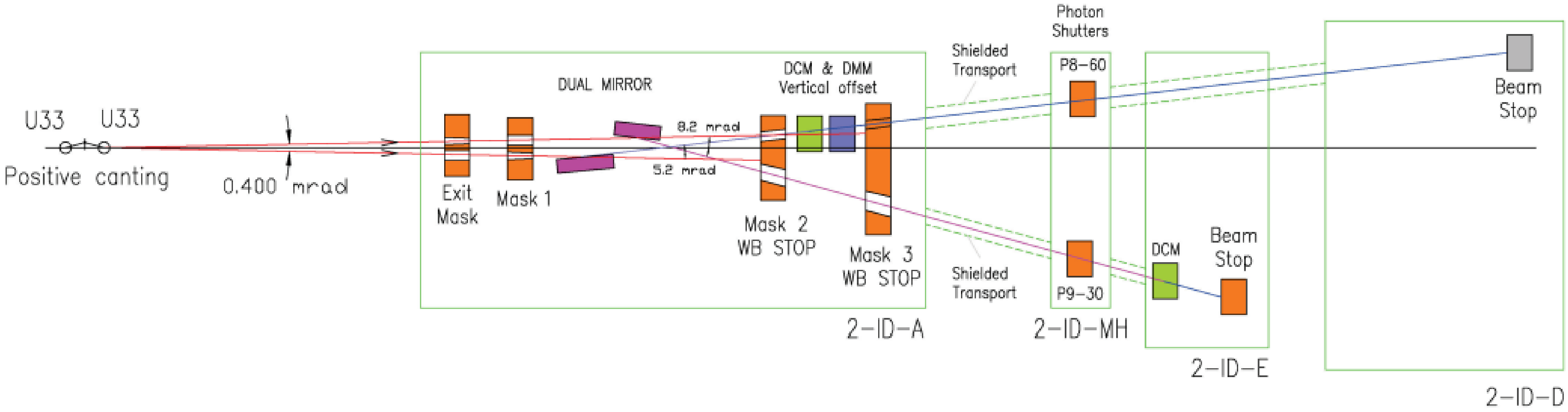


Corrector Dipole

Example)

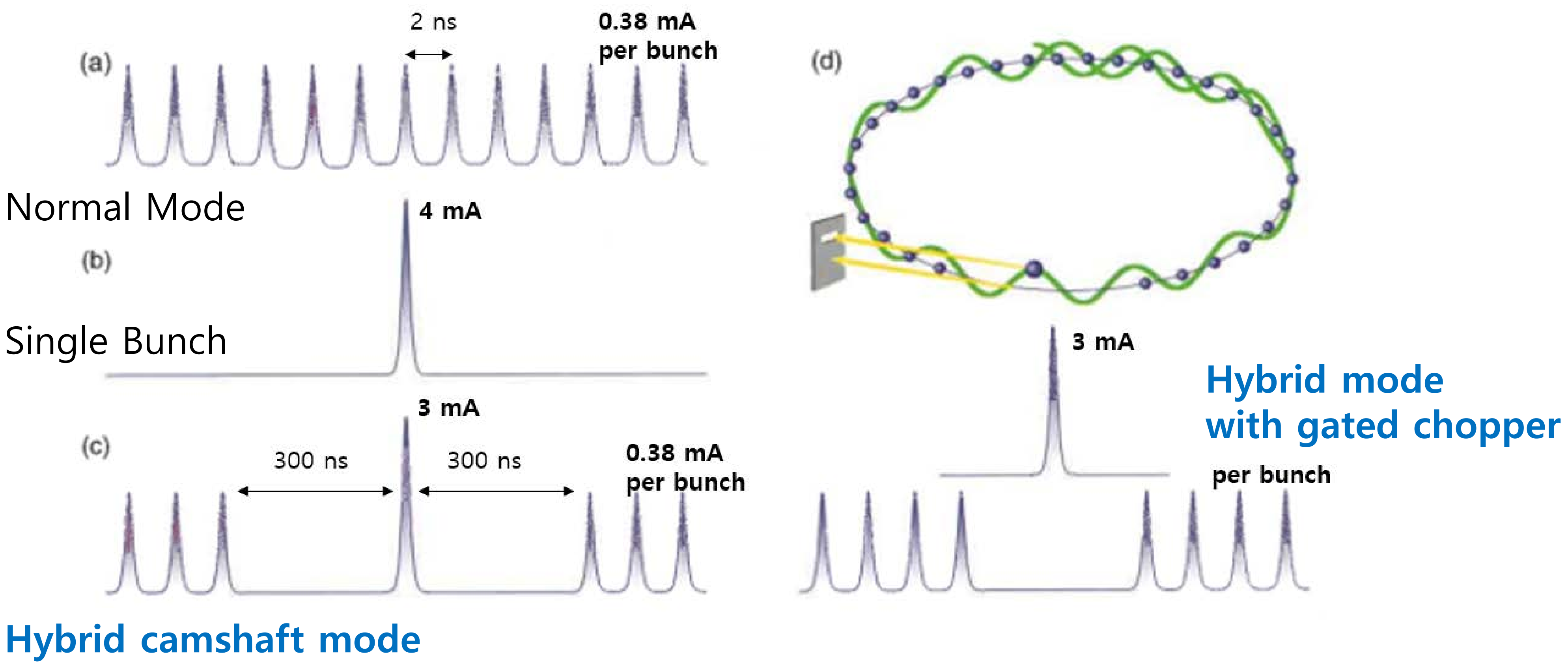
- APS 2-ID BEAMLINE, UPGRADE TO CANTED CONFIGURATION

- **0.4 mrad canted**
  Two U33(L=2.4 m)



https://accelconf.web.cern.ch/medsi2016/posters/wepe18_poster.pdf

Considering Timing Structure (for Phase-II)



Priority support for industries

Support for Academic R&D

Beamline	Photon Energy	Resolution	Photon Source	Exp.	Application
① **BioPharma-BioSAXS**	**5~25 keV**	SAXS: 1 Å 이하 ΔE/E < 10^{-4}	**IVU24**	① Bio-SAXS	Bio.
② **Material Structure Analysis**	5~40 keV	ΔE/E < 10^{-4}	**IVU24**	① HRPD, XRD ② XAFS	Material Science, Energy material
③ **Soft X-ray Nano-probe**	0.1~5.0 keV	sub-micro beam ΔE/E>15×10^{-4}@1keV	**EPU78 +IVU24**	① XAS ② XPS	Semiconductor, Material Science * Tandem U., Two Branched Beamline
④ **Nanoscale Angle-resolved Photoemission Spectroscopy**	0.1~2 keV Optimize: 50 ~200 eV	100 nm < ΔE/E < 10^{-4}	**EPU98**	① Nano-ARPES	Semiconductor, Material Science *Two Branched Beamline
⑤ **Coherent X-ray Diffraction**	3~30 keV	sub-micro beam	**IVU24**	① XRD ② CDI	Semiconductor, Material Science Geosciences, Chemistry
⑥**Coherent Small-angle X-ray Scattering**	4~40 keV Optimize: 8-17 keV	~ a few nm ~ μm ΔE/E < 2×10^{-4}	**IVU20**	① SAXS/WAXS (GI 기법 포함) ② XPCS	Material Science, Chemistry
⑦ **Real-time X-ray Absorption Fine Structure**	5~40 keV	~ a few μm	**IVU24**	① XAFS	Material Science, Environments, Geosciences, Chemistry
⑧ **Bio Nano crystallography**	5~20 keV	1 Å <	**IVU20**	① MX	Bio.
⑨ **High Energy Microscopy**	5 ~ 100 keV	Spatial R. ~ 0.1μm	Centerbend	① Projection imaging	Material Science, Energy material, Bio * Spatial Resolution : 0.1 μm→0.3-0.5 μm
⑩ **Nano-probe**	5~25 keV	~50nm NanoProbe	**IVU24**	① Ptychography /XRF	Semiconductor, Material Science, Geosciences,

Summary
Goal : Prepare Another Successful Playground for Science

- Overview of beamline construction status.
- High Heat Load devices(PBPM, Mask, DCM) need study & developing.
- Human resources training and planning.
- Need to adapt and introduce for contemporary experimental method.

From Naturejobs Blog

Thanks to:

All 4GSR Project Supporting Division