Beamline Overview



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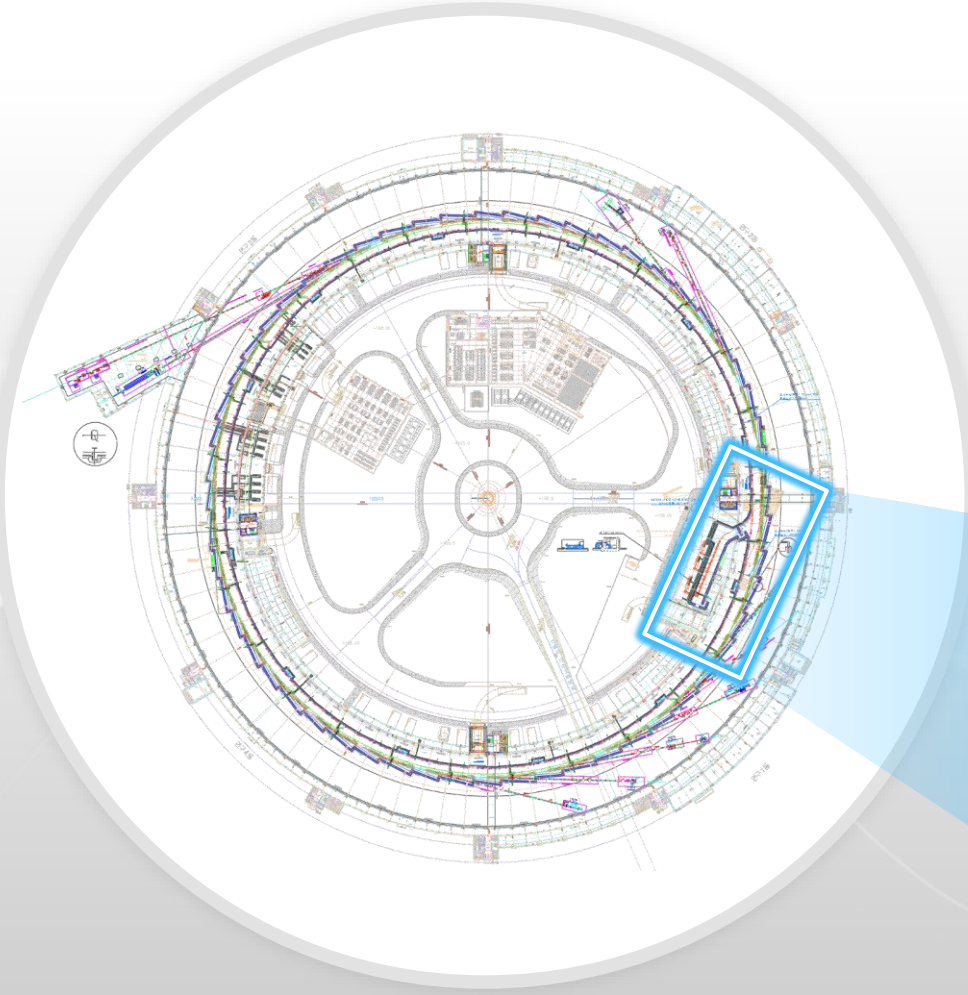
Outline of Korea-4GSR Beamline Specification

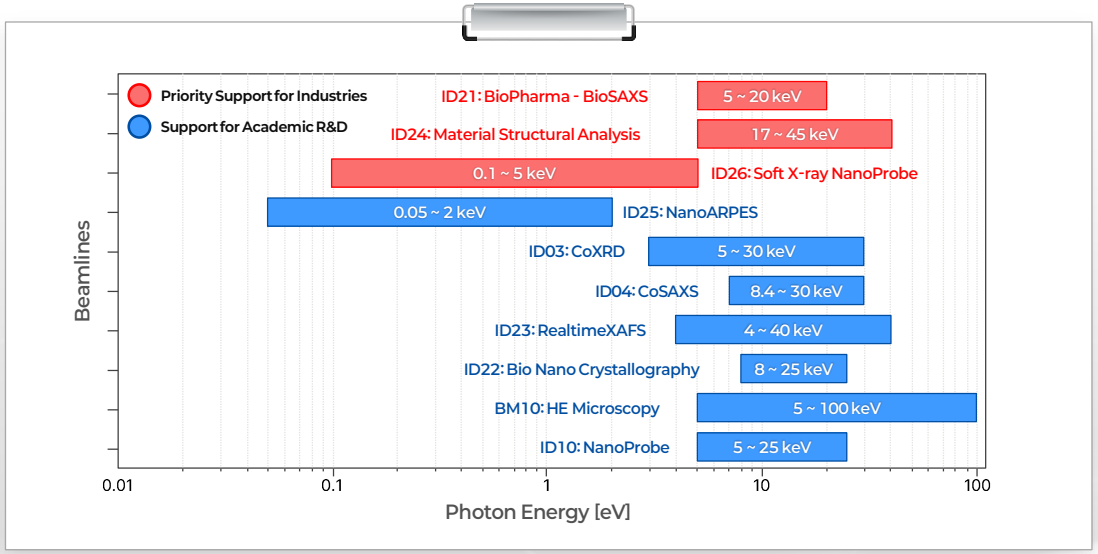
Priority support for industries

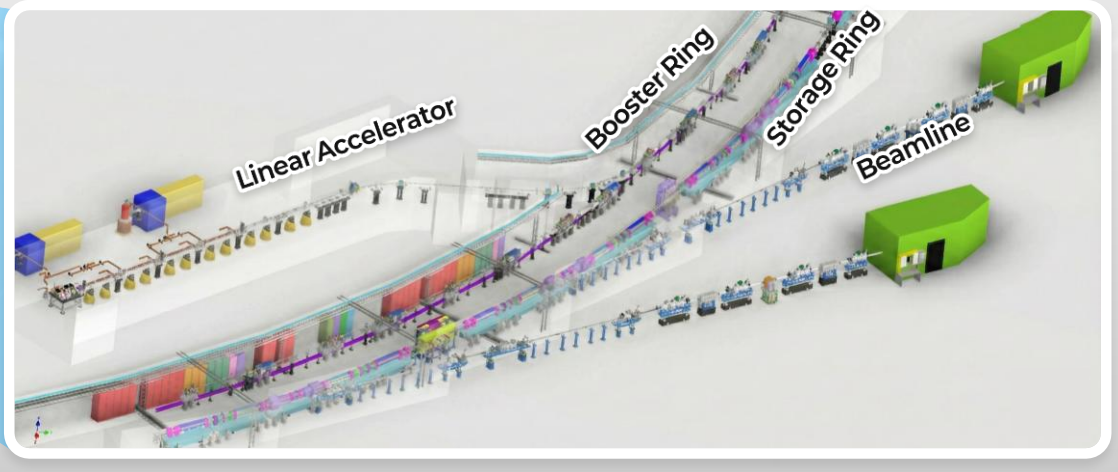
Support for Academic R&D

	Beamlines	Photon Energy	Photon Source	Exp.	Application
#1	ID21 BioPharma-BioSAXS	8 ~ 23 keV	**IVU20**	Bio-SAXS	Biopharmaceuticals, Structural Biology, Bio Materials, Soft Matter
#2	ID24 Material Structure Analysis	17 ~ 45 keV	**IVU16**	HRPD, XRD XAFS	Material Science, Energy Materials, Quantum Materials
#3	ID26 Soft X-ray NanoProbe	0.1 ~ 5 keV	**EPU78 +IVU24**	(AP)XPS, XAS	Semiconductor, Material Science Energy Materials, Quantum Materials
#4	ID25 Nanoscale Angle-resolved Photoemission Spectroscopy	0.05 ~ 2 keV Optimized: 0.05 ~ 0.2 keV	**EPU98**	Nano-ARPES	Semiconductor, Material Science, Quantum Materials
#5	ID03 Coherent X-ray Diffraction	5 ~ 30 keV	**IVU22**	XRD, CDI	Semiconductor, Material Science Geoscience, Chemistry, Quantum Materials
#6	ID04 Coherent Small-angle X-ray Scattering	8.4 ~ 30 keV Optimized: 8 ~ 17 keV	**IVU20**	SAXS/WAXS (GI-SAXS), XPCS	Material Science, Chemistry, Quantum Materials
#7	ID23 Real-time X-ray Absorption Fine Structure	4 ~ 40 keV	**IVU24**	XAFS	Material Science, Environments, Geoscience, Chemistry, Quantum Materials
#8	ID22 Bio Nano crystallography	8 ~ 25 keV	**IVU20**	MX	Bio.
#9	BM10 High Energy Microscopy	20 ~ 150 keV	**Center-bend**	Projection imaging	Material Science, Energy Materials, Bio Science, Quantum Materials
#10	ID10 NanoProbe	5 ~ 25 keV	**IVU24**	Nano-XRF/XRD/XAFS, Ptychography	Semiconductor, Material Science, Geoscience, Chemistry, Energy Materials, Quantum Materials

Ground Plan for 4GSR







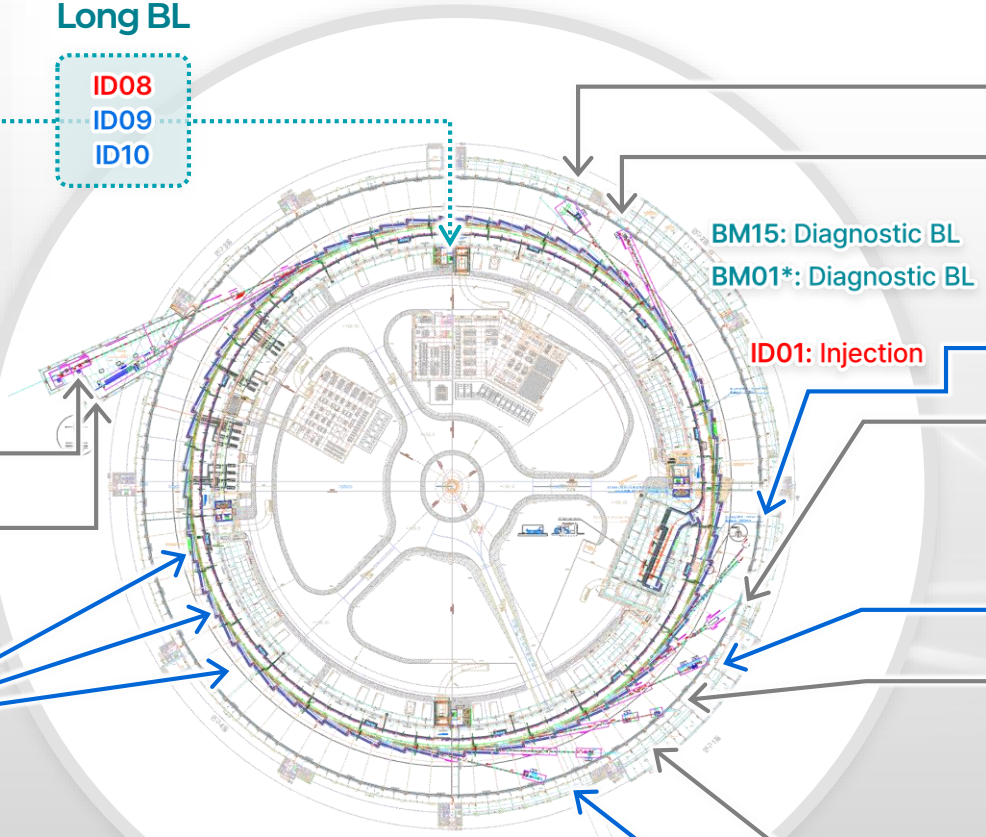
Ground Plan for 4GSR

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28 straight sections

- **Assigned[13 + 3(*0.5)]**
  3 : RF cavity 9 : Beamline
  1 : Injection 3(*0.5) : H. Cavity
- **Remains : [12 + 3(*0.5)]**

Long BL
ID08
ID09
ID10



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

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

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

Coherence Science
- ID03: #05 CoXRD
- ID04: #06 CoSAXS

Soft X-ray Science
- ID26: #03 Soft X-ray NanoProbe
- ID25: #04 NanoARPES

Material Science
- ID24: #02 Material Structure Analysis
- ID23: #07 Real-time XAFS

Bio Science
- ID22: #08 Bio Nano crystallography
- ID21: #01 BioPharma-BioSAXS

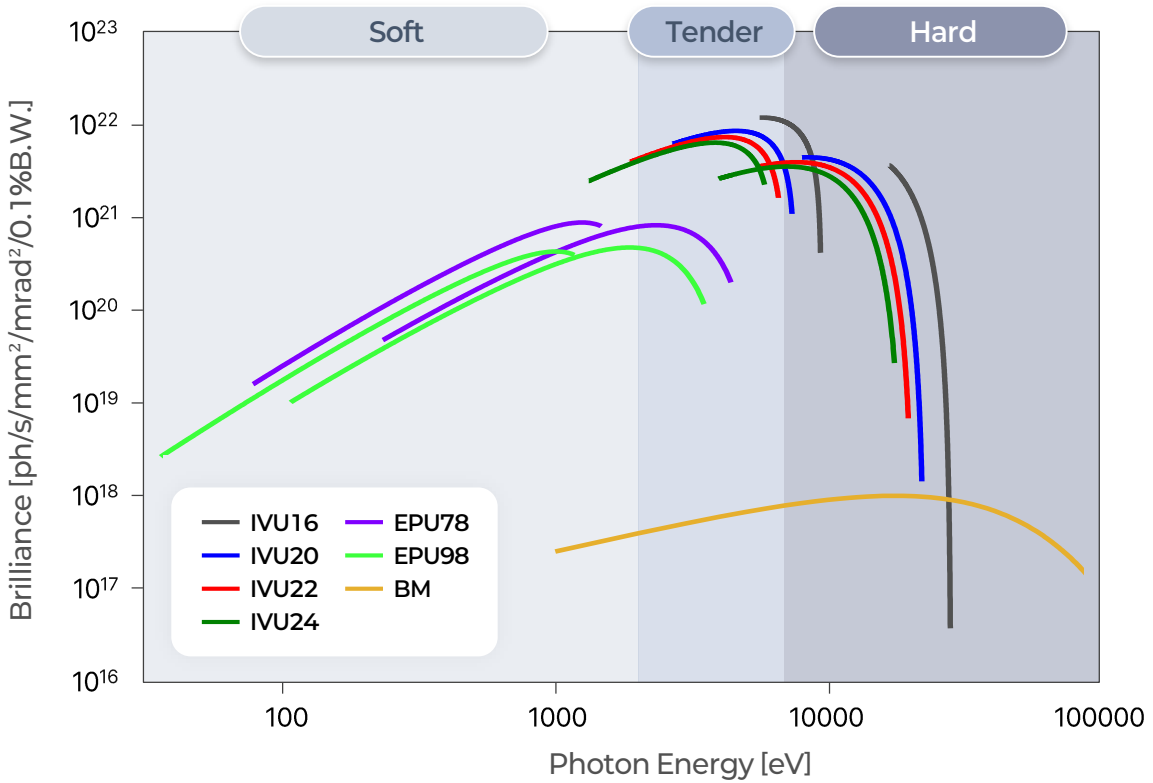
- Priority Support for Industry
- Support for Academic R&D

Photon Source Specification

Undulator	(Unit)	IVU16	IVU20	IVU22	IVU24	IVU24	EPU78	EPU98	BM	PLS-II (IVU20)
Beamline #	[mm]	**ID24** Mat. St. Anal.	**ID04** CoSAXS **ID21** BioPharma **ID22** BioNX	**ID03** CoXRD	**ID10** NanoProbe **ID23** RealTime XAFS	**ID26** SX-ray NanoProbe(I)	**ID26** SX-ray NanoProbe(II)	**ID25** NanoARPES	**BM10**	
Period Length	[mm]	16	20	22	24	24	78	98	-	20
Periods		185	148	134	123	60	23	36	-	68
Device Length	[m]	3	3	3	3	1.5	2	3.631	0.186	1.4
K_{max} value		1.172	1.904	2.315	2.745	2.745	K_V6.948 K_C4.390 K_H5.652	K_V9.238 K_C6.070 K_H8.043	-	1.811
B_{max}	[T]	0.785	1.021	1.127	1.225	1.225	B_V0.954 B_C0.602 B_H0.776	B_V1.0725 B_C0.692 B_H0.9096	2	0.969
Gap_{min}	[mm]	5	5	5	5	5	15	15	-	5
ε_{1st}	[eV]	5628.6	2696.1	1876.6	1327.8	1327.8	77.49 [V] / 96.0[C] / 114.84 [H]	35.5 [V] / 40.9 [C] / 46.49 [H]	[E_c] 21280.8	1618.78
Total Power	[kW]	7.38	12.49	15.16	17.93	8.75	6.61 [V] / 5.27 [C] / 4.37 [H]	13.75 [V] / 11.87 [C] / 10.42 [H]	1357.83	2.91
Max.Power Density	[W/mrad²]	154.3	164.2	165.2	165.4	80.7	24.3 [V]	38.02 [V]	Lin. Pow. Density (kW/mrad) 0.216	22.5
Photon Beam Divergence	[mrad]	$\Sigma_{x'}$ 0.00679 $\Sigma_{y'}$ 0.00626	$\Sigma_{x'}$ 0.00930 $\Sigma_{y'}$ 0.00892	$\Sigma_{x'}$ 0.01100 $\Sigma_{y'}$ 0.01068	$\Sigma_{x'}$ 0.01293 $\Sigma_{y'}$ 0.01265	$\Sigma_{x'}$ 0.01825 $\Sigma_{y'}$ 0.01806	$\Sigma_{x'}$ 0.06684 [V] $\Sigma_{y'}$ 0.06679 [V] $\Sigma_{x'}$ 0.06004 [C] $\Sigma_{y'}$ 0.05998 [C] $\Sigma_{x'}$ 0.05495 [H] $\Sigma_{y'}$ 0.05489 [H]	$\Sigma_{x'}$ 0.07246 [V] $\Sigma_{y'}$ 0.07241 [V] $\Sigma_{x'}$ 0.06745 [C] $\Sigma_{y'}$ 0.06740 [C] $\Sigma_{x'}$ 0.06333 [H] $\Sigma_{y'}$ 0.06327 [H]		$\Sigma_{x'}$ 0.0341 $\Sigma_{y'}$ 0.0171

Beamline Present Status

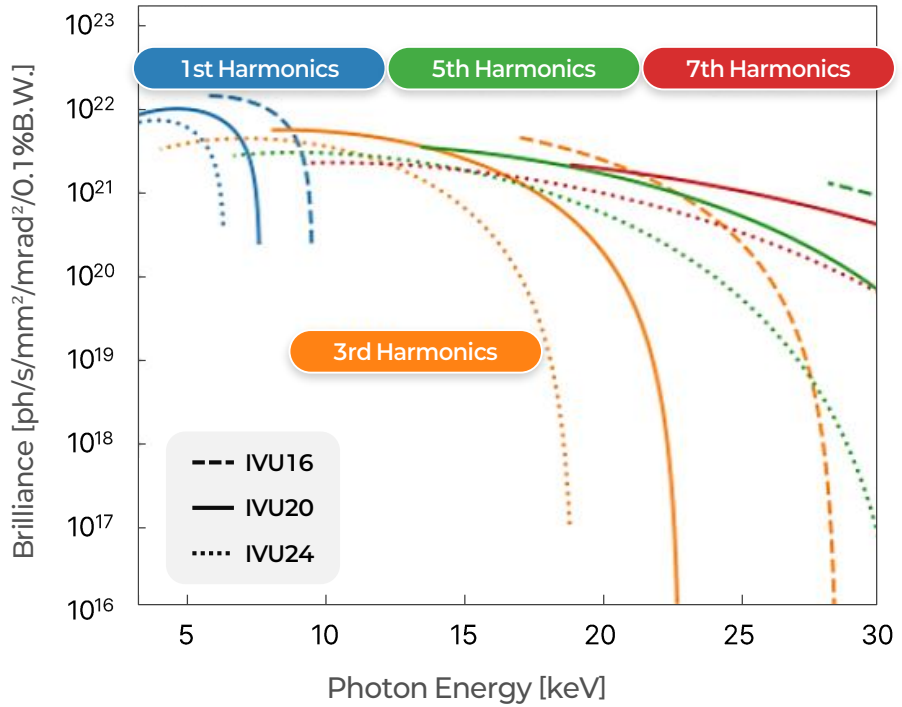
Brilliance for All Photon Sources, BM, EPU78, EPU98, IVU16, IVU20, IVU22, and IVU24



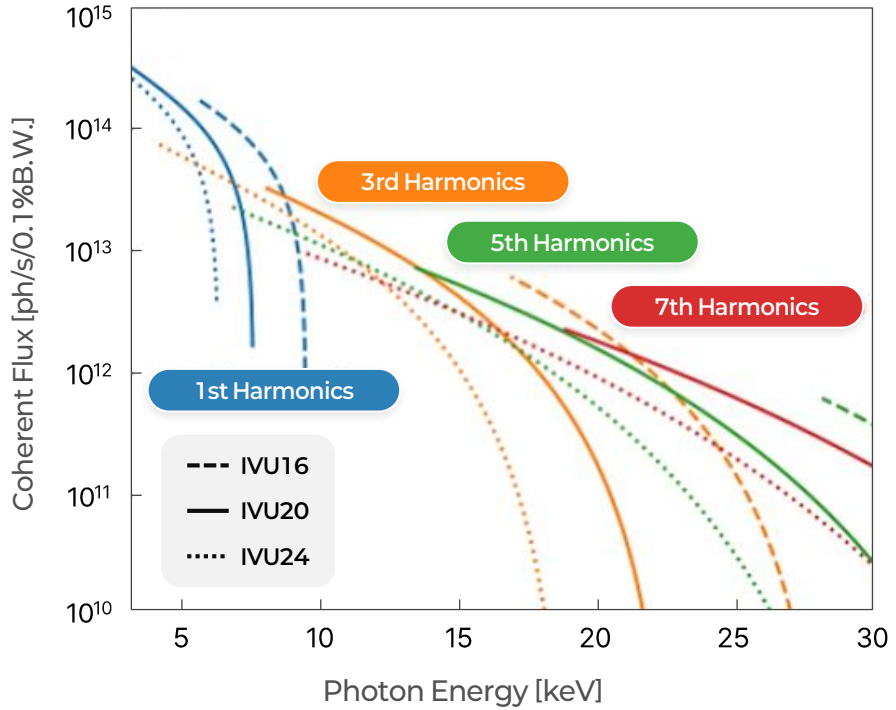
Beamline Present Status

Brilliance and Coherent Flux for IVU16, IVU20, and IVU24

a



b



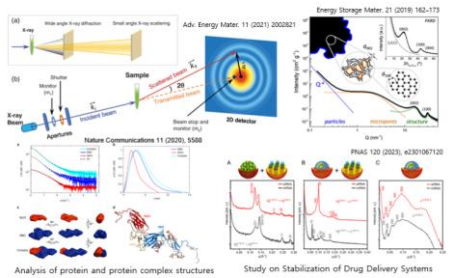
Bio Science

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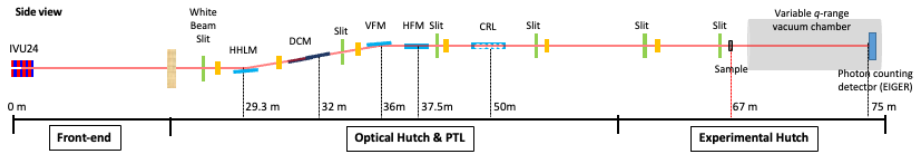
ID21 BioPharma-BioSAXS

Priority to Industries

Study on 3D structural characteristic of biological molecule systems



Photon Source	In Vacuum Undulator 20
Energy Range (mainly)	8 ~ 23 keV (12.4)
Energy resolution	< 2 × 10^{-4}
Beam flux (ph/s)	> 1 × 10^{13}
Beam size (μm²) H × V, FWHM	~ 200 × 200 ~ 40 × 10
Spatial resolution	8 ~ 3800 Å

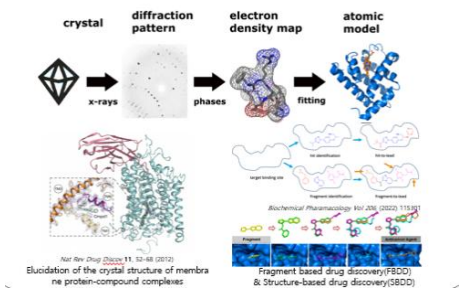


- Introduction of an automatic sample exchange robot to facilitate high-throughput experiments.
- Variable q-range vacuum chamber allows rapid adjustment of sample-to-detector distance within a range of 0.5 m to 8 m, enabling efficient analysis of various systems.
- Supporting various sample environments for the structural analysis of biological molecules.

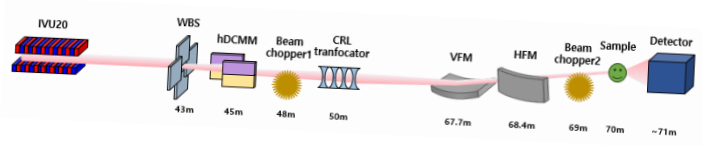
ID22 Bio Nano crystallography

Priority to Academic R/D

Structure determination of micro- to nano-sized protein crystals and drug discovery support



Photon Source	In Vacuum Undulator 20
Energy Range (mainly)	8 ~ 25 keV (12.4 and 20)
Energy resolution	< 2 × 10^{-4} (DCM), ~ 1 % (DMM)
Beam flux (ph/s)	> 1 × 10^{14}
Beam size (μm²) H × V, FWHM	1 × 1 ~ 50 × 50 @ 12.4 keV 1 × 1 ~ 5 × 5 @ 20 keV
Spatial resolution	0.7 Å ~ 3.5 Å
Measurement frequency	> 100 Hz



- Delivers a minimum beam size of 1 μm with high photon flux, enabling serial and in-situ crystallography experiments on challenging protein crystal samples.
- Supports high-throughput data collection through an automated sample exchange robot.
- Operates a dedicated sample preparation laboratory for drug discovery applications, including fragment library screening.

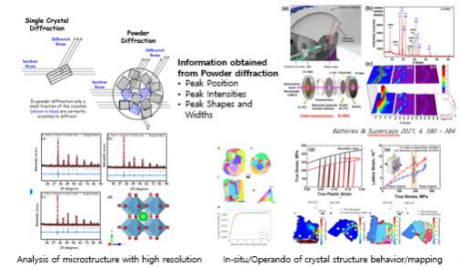
Material Science

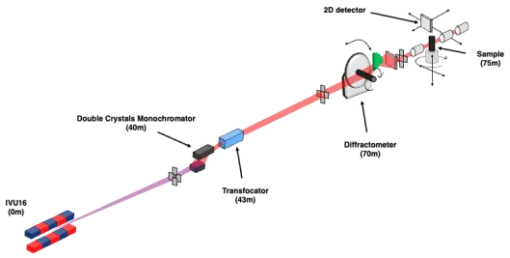
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Priority to Industries

ID24 Material Structure Analysis

Analysis of microstructure and phase transition of crystalline materials with high resolution





Photon Source	In Vacuum Undulator 16
Energy Range	17 ~ 45 keV (optimized: 33)
Energy resolution	< 2 × 10^{-4}

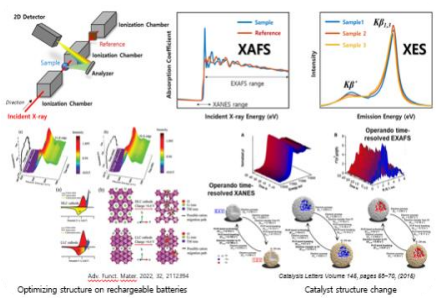
Beam flux (ph/s)	1 × 10^{13}
Beam size (μm²) H × V, FWHM	Natural: 1000 × 1000 Focused: 50 × 50

- Delivers a beam with low divergence and low harmonic order, exceeding 30 keV via an insertion device for high-resolution powder diffraction (HRPD).
- Utilizes HRPD as the primary technique, with an automated sample changer for enhanced efficiency and additional analysis via dedicated experimental setups.
- Supports varied sample environments (temperature, gas, atmosphere) with real-time XRD analysis.

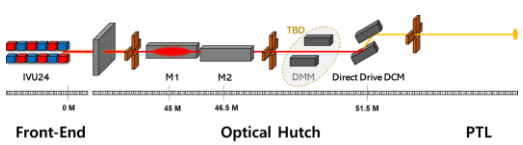
Priority to Academic R/D

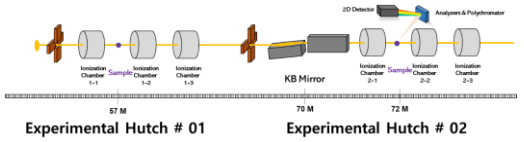
ID23 Real-Time XAFS

Studying reaction dynamics on sub-second time scales and states of electrons



Photon Source	In Vacuum Undulator 24	
Energy Range	4 ~ 40keV	
Energy resolution	Si (111): 1.4 × 10^{-4}	Si (311): 3.0 × 10^{-5}
Beam flux (ph/s)	Tuned Undulator: 6.8 × 10^{13} @ 10 keV	Tapered Undulator: 2.4 × 10^{12} @10 keV
Beam size (μm²) H × V, FWHM	Focused mode: 10 × 10 μm²	Unfocused mode: 1 × 0.8 mm²
Measurement time	XAS : 1 ~ 20 min Quick XAS : > 1 s XES : a few min	





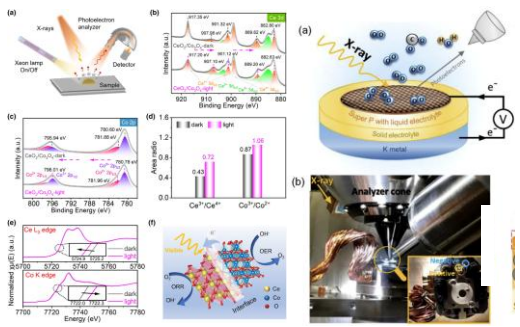
- By utilizing the IVU24, the ID23 beamline provides advanced spectroscopies, including Quick XAS, operando/in-situ XAS, HERFD-XAS, and XES.
- Such capabilities are expected to support research on both national strategic technologies and fundamental academic science.

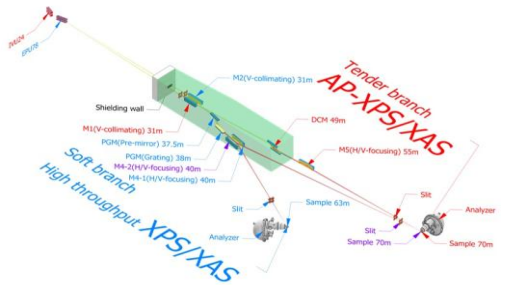
Soft X-ray Science

ID26 Soft X-ray NanoProbe

Priority to Industries

Probing the electronic structure, chemical states, and nanoscale morphology of materials





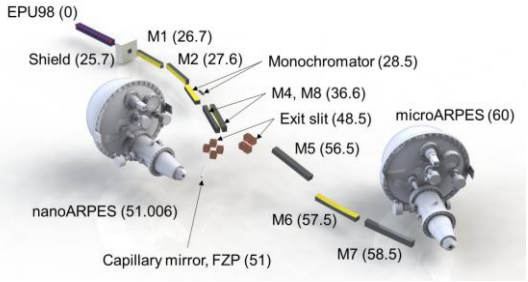
Branch	Tender X-ray	Soft X-ray
Photon Source	In Vacuum Undulator 24 (1.5 m)	Elliptically Polarizing Undulator 78 (2 m)
Energy Range (mainly)	2 ~ 5 keV	0.1 ~ 3 keV
Energy resolution	< 10^{-4} @ 4 keV	1 × 10^{-4} ~ 2 × 10^{-4}
Beam flux (ph/s)	~ 1 × 10^{14}	~ 6 × 10^{13}
Beam size (μm²) H × V, FWHM	12 × 5	10 ~ 400

- Canted array undulator (IVU24 + EPU78) enables simultaneous multi-experiment capability
- The soft to tender X-ray energy range (0.1 ~ 5 keV) allows analysis of various elements and chemical states using XPS and XAS
- In-situ operando experiments can be performed under various conditions (From ultra-high vacuum to ambient pressure)

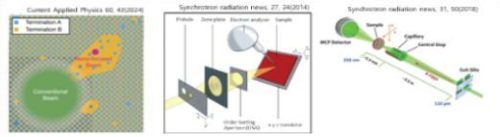
ID25 NanoARPES

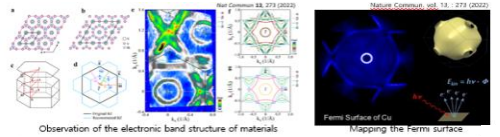
Priority to Academic R/D

Mapping of the Fermi surface and observation of the electronic band structure of materials



Branch	Micro ARPES	Nano ARPES
Photon Source	Elliptically Polarizing Undulator 98 (3.6 m)	
Energy Range	0.05 ~ 2 keV	
Energy resolution	< 1 × 10^{-4}	< 3 × 10^{-4}
Beam flux (ph/s)	~ 1 × 10^{13}	
Beam size (μm²) H × V, FWHM	10 × 10	1 × 1





- Enables to observe the electronic band structure, which indicates physical properties, such as electrical, optical and magnetic characteristics.
- From various polarization modes of the undulator, Enables the analysis of magnetic properties and asymmetrical electronic structures
- Operates with two end stations: microARPES(beam size: 10 × 10 μm2) and nanoARPES (beam size : 1 × 1 μm2)

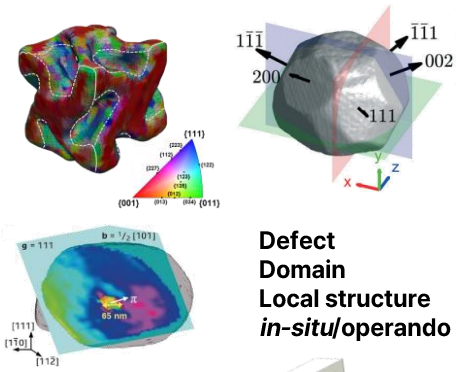
Coherence Science

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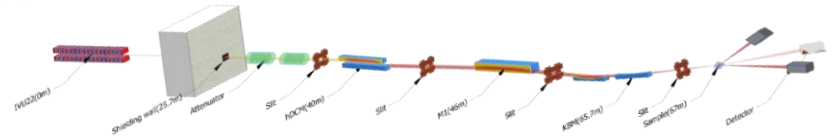
ID03 CoXRD

Priority to Academic R/D

Fundamental investigation of local distortions and defect structures via coherent X-ray scattering



Photon Source	In Vacuum Undulator 22
Energy Range (mainly)	5 ~ 30 keV (6 keV)
Energy resolution	< 2 × 10^{-4}
Beam flux (ph/s)	~ 5.6 × 10^{12} @ 6 keV, coherent
Beam size (μm²) H × V, FWHM	1 (KB mirror), 2 ~ 10 (Diamond CRL)
Techniques	CDI, μXRD



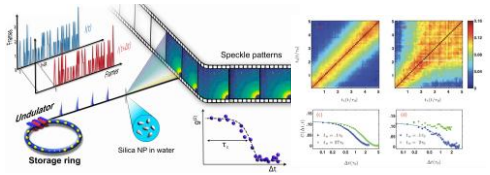
- Exploiting the high coherence and brightness of the fourth-generation storage ring.
- Coherence-preserving beamline architecture designed for high-fidelity diffraction and imaging experiments.
- Providing exceptional sensitivity to nanoscale and local structural variations

ID04 CoSAXS

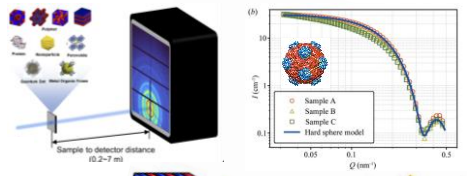
Priority to Academic R/D

Coherent Small-Angle X-ray Scattering for Dynamics of Soft and Complex Materials

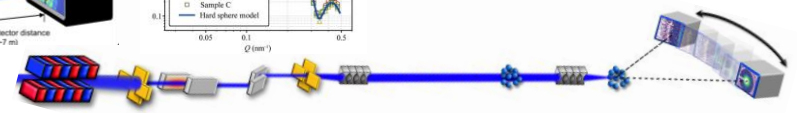
X-ray Photon Correlation Spectroscopy (XPCS)



Small-Angle X-ray Scattering (SAXS)



Photon Source	In Vacuum Undulator 20
Technique	μSAXS/WAXS, XPCS
Energy Range	8.4 ~ 30 keV
Energy resolution @ 10 keV	Si (111): ~ 1.3 × 10^{-4} Si (311): ~ 2.7 × 10^{-5}
Beam flux (ph/s)	1.3 × 10^{15} (0.1% B.W.)
Coherent Beam flux (ph/s)	2.6 × 10^{13} (0.1% B.W.)
Beam size (μm²) H × V, FWHM	5 × 5 ~ 200 × 200
Detector	EIGER 4M: General purpose TIMEPIX: Nanosecond XPCS



- Utilizes the high brightness and coherence of the 4GSR for speckle-based dynamic scattering, with SAXS as the primary method and GI/WAXS as complementary modes.
- Preserves coherence while providing tunable beam sizes and variable detector distances, ensuring flexibility for in-situ/operando studies and scalability for future developments.

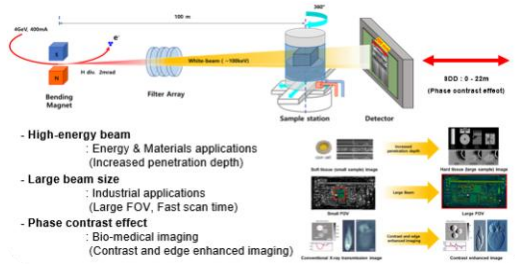
Imaging Science

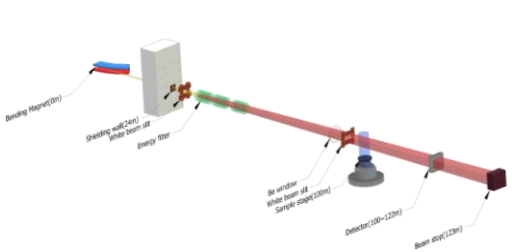
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BM10 High Energy Microscopy

Priority to Academic R/D

High-quality multiscale 3D image analysis using phase contrast effects





Photon Source	Bending Magnet (2 T)
Energy Range	20 ~ 150 keV (E_c: 21.2 keV)
Beam size (FWHM)	200 mm × 25 mm @ 100 m

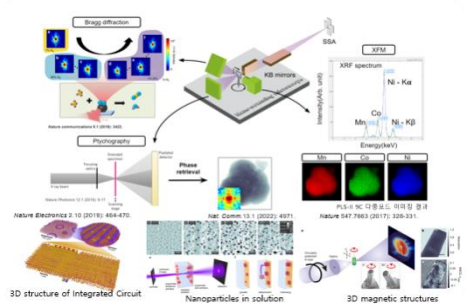
Spatial resolution	> 1.0 μm
Technique	Projection imaging
Sample dimensions	H = 1.0 m, D = 0.3 m (100 kg)

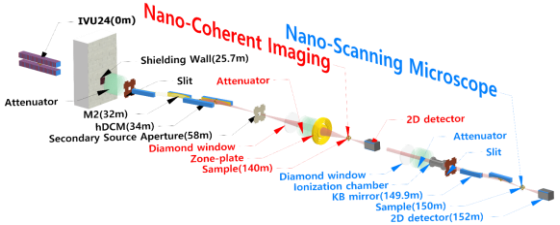
- The high energy microscope beamline is based on projection image utilizing high-energy X-ray beams above 100keV and a long beamline of over 100 meters.
- The bending magnet illuminates the sample at a distance of 100 m with a beam of 200 mm width and 25 mm height, and acquires a high quality projection image by phase contrast effect.
- Phase contrast imaging improves spatial resolution and contrast, allowing researchers to resolve finer structural details in three dimensional imaging and expand the range of observations in materials and biological specimens.

ID10 NanoProbe

Priority to Academic R/D

3D nanoscale quantitative analysis of complex systems





Photon Source	In Vacuum Undulator 24
Energy Range (mainly)	5 ~ 25 keV (8 ~ 10)
Energy resolution	< 2 × 10^{-4}

Beam flux (ph/s)	10^9 ~ 10^{12}
Beam size (nm^2) H × V, FWHM	50 × 50
Spatial resolution	< 50 nm (Scanning) < 10 nm (Imaging)

- Provides high-resolution imaging over a wide area and simultaneous elemental mapping through multimodal analysis using scanning diffraction imaging and X-ray fluorescence microscopy.
- Aims to track reactions and defect growth in systems like batteries and catalysts, enabling quantitative nanoscale analysis of complex functional materials under manufacturing and operational environments.

Thank You



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