The 1st Workshop for Future Science in Next Generation SR

Current Status and Future Plans of Korea-4GSR

(Multipurpose Synchrotron Radiation Project)

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Project Director

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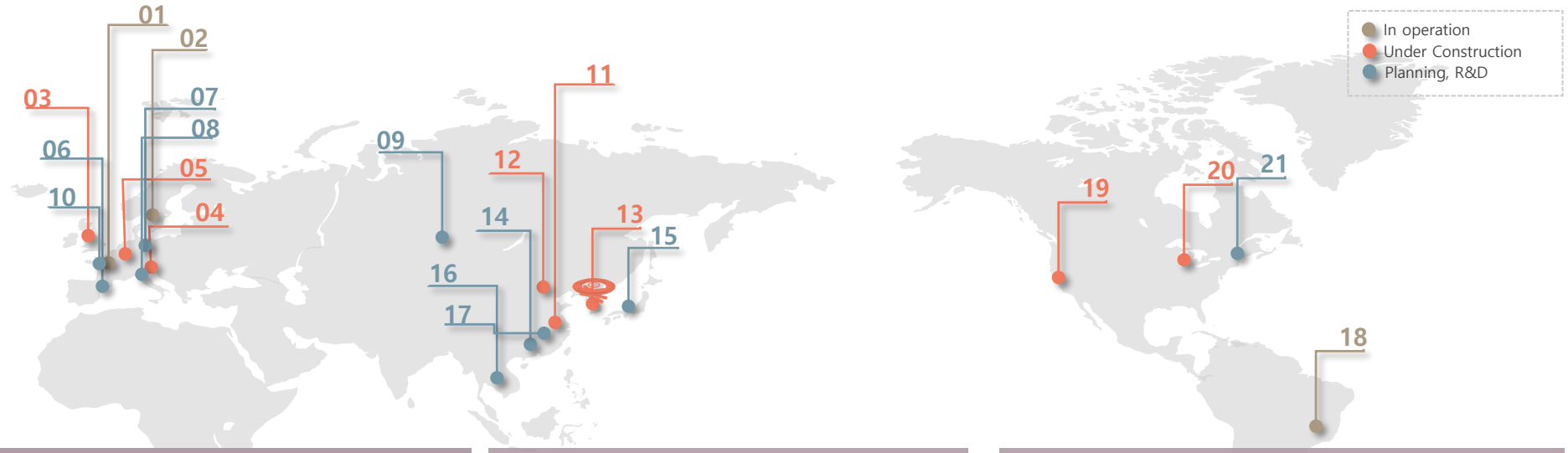
CONTENTS

I Overall Project

1 4GSRs in the world



Europe & Russia

In operation

01	ESRF-EBS	EU	2015-2022
02	MAX-IV	SE	2010-2016

Under Construction

03	Diomond-II	UK	2027-2029
04	Elettra 2.0	IT	2025-2026(Dark)
05	SLS 2.0	CH	2023-2025

Planning, R&D

06	ALBA II	ES
07	BESSY III	DE
08	PETREA-IV	DE
09	SKIF	-
10	SOLEIL II /	FR

Asia

Under Construction

11	HALF	CN	2023-2028
12	HEPS	CN	2019-2025
13	Korea-4GSR	KR	2021-2029

Planning, R&D

14	SAPS	CN
15	Spring-8-II	JP
16	SPS-II	TH
17	WHPS	CN

America

In operation

18	Sirius	BR	2015-2022

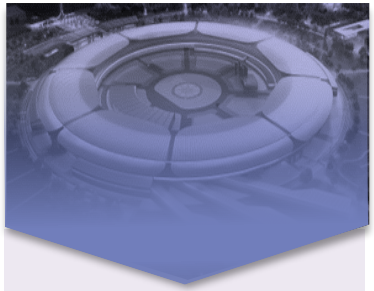
Under Construction

19	ALS-U	USA	2026-2027(Dark)
20	APS-U	USA	2023-2024(Dark)

Planning, R&D

21	NSLS-II	USA

2 Overview of Korea-4GSR



Location of Ochang

Period & Budget

Period	2021~2029
Budget	1.1643 Trillion KRW = USD 834 M

Land & Building

Land	540,000 m^2
Building	69,959 m^2

Location

Ochang,
Cheongju-si,
Chungcheongbuk-do

Characteristics

Beam Energy	4 GeV
Beam Emittance	less than 100 pm·rad (Design: 62 pm·rad)
Circumference	800 m
Beamlines	10 in the first phase (more than 40 in final phase)
Accelerator	Gun, Injector LINAC, 4 GeV Booster and Storage Ring
Lattice	Hybrid 7 Bend Achromat (H7BA)
-	Normal conducting RF cavity and 500 MHz

3 Road Map as User Facility

Vision

World-leading synchrotron radiation for transformative science

- 4 GeV, 400 mA, ε < 100 pm·rad e-beam
- Cutting-edge beamlines utilizing unprecedented radiation properties

Mission

Achieve Design Performance

- Complete accelerator & beamline construction
- Ensure on-time development and commissioning

Build Operational & Scientific Capability

- Accumulate next generation R&D team
- Establish advanced science programs

Map

2024 Progress without delay

- Structuring the organization
- Project management setup

2027 Project center-driven

- Development and Inspection
- Unified operating system

2029 Commissioning

- Assemble and Install on time
- Performance verification

2030 Operation

- Transit to operation mode
- Spread into science community

Strategy

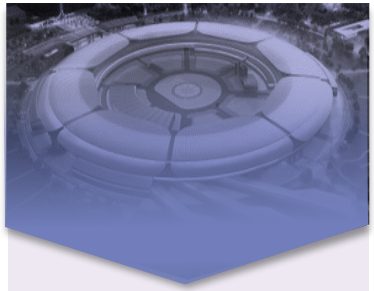
Phase 1 (~2030) Establishing core facility infrastructure

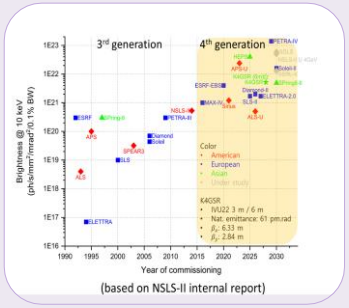
- Collaborative development with KBSI and PAL
- Accelerator development with proven technology
- Co-development of high-demand, user-prioritized beamlines
- Future S&T manpower for operations and Phase 2 expansion

Phase 2 (2031~) Strengthening research capabilities & infrastructure

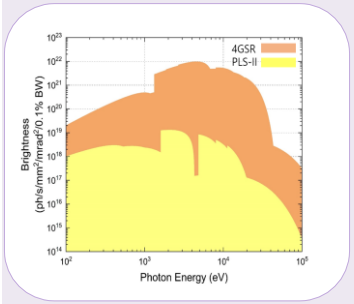
- Globally competitive photon science platform through innovation and integration
- Industry-engaged innovation hub
- Integrated science ecosystem
- Science-driven future beamline expansion
- AI-augmented operations for optimization, diagnostics, and autonomous control and meas.

4 Features of Korea-4GSR





(based on NSLS-II internal report)



Characteristics of photon beam

- Optimal performance in the range of 10~30 keV (Still high brilliance @ 1 keV)
- Photon energy up to 100 keV

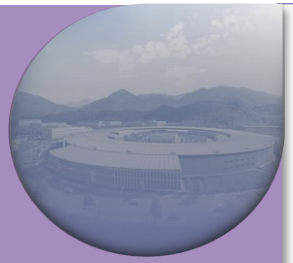
Utilization of validated technologies for the accelerators and beamlines

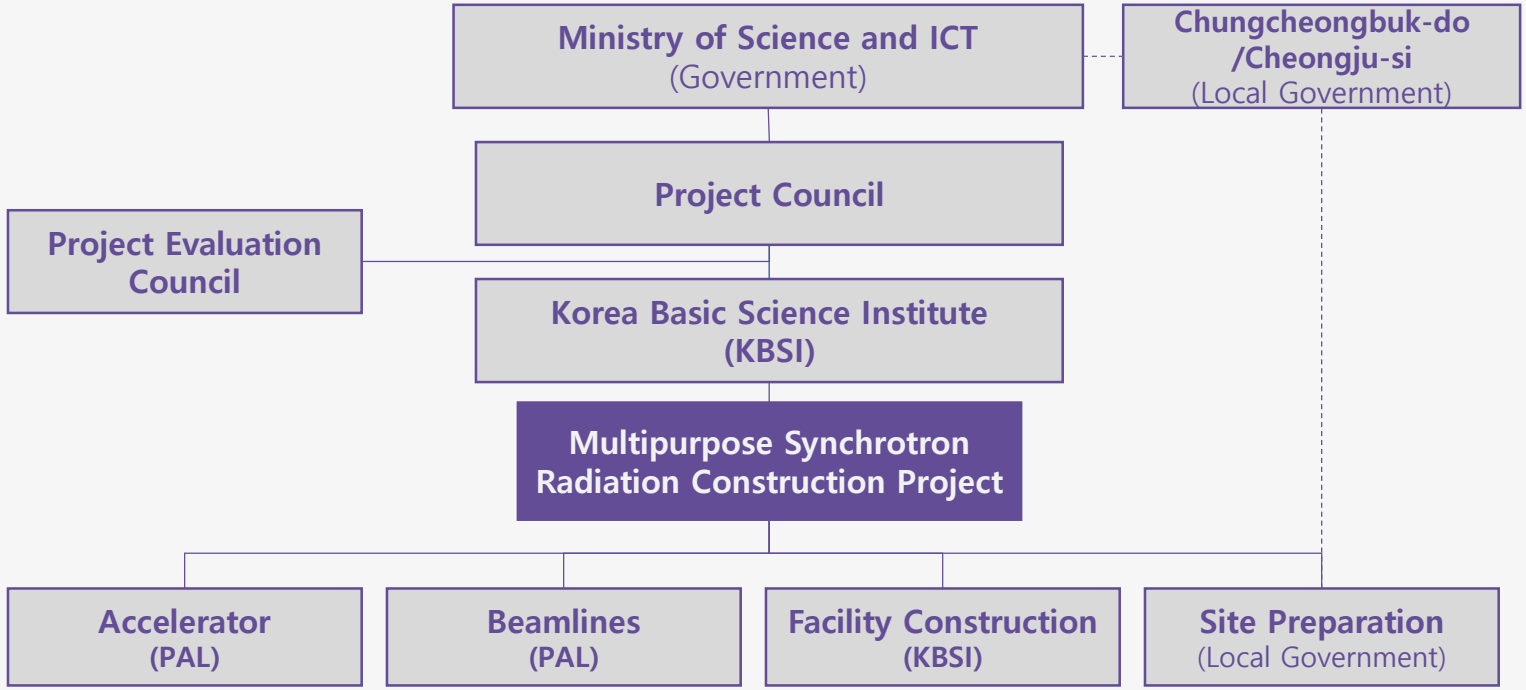
- Booster ring, injected by 200 MeV LINAC
- Conventional injection scheme (off-axis injection with 4 kickers system)
- Comparatively demonstrated technologies for core systems (RF, magnet)
- Stay on schedule and full performance within 3 years operation

Reinforcement of topics requiring improvement

- Ultra-stable beam
- Photon beam based diagnostics (Ground motion, ID, etc. issues)
- Reinforcement of radiation source
- Data management and service software system
- Enable time-resolved experiments
- Flagship beamlines and cutting edgy science program

5 Project Governance





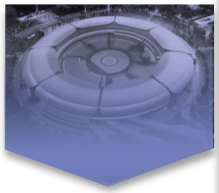
KBSI, the leading institute to carry out the project

Responsible for **Facility Construction and Project management**

PAL, the Joint institute as the partner

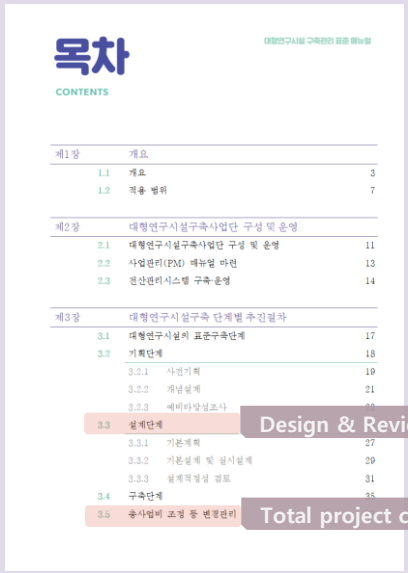
Responsible for **Accelerator and Beamline construction**

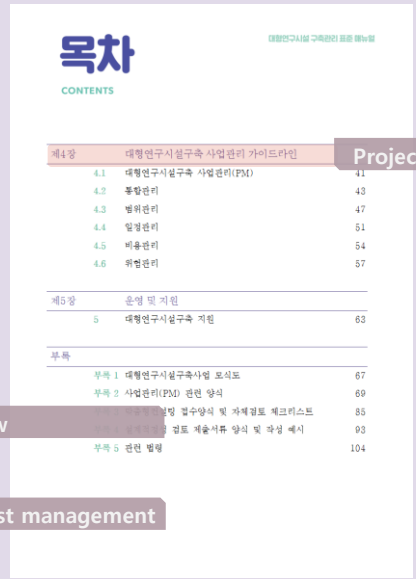
6 Recent Management Systems for Large-Scale Project in Korea



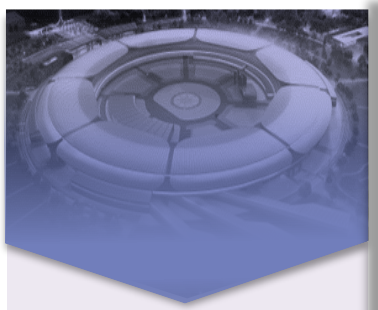
- **The first accelerator project to consider professional PM in Korea**
- **The first accelerator project to consider total project cost management**
  - Design review with three stages (3rd stage in this system ~ CD3 in DOE)
  - Budget management in each categorized items
    (return of surplus budget or further review for shortfall budget in each items)

「Large-scale research facility project Management manual」

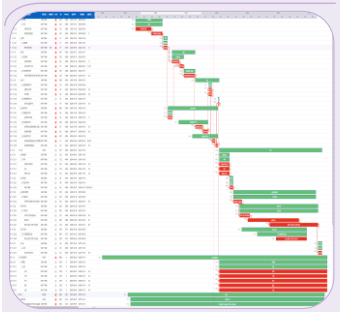




7 Project Management



Critical Path Method in PMS



Risk Management Chart

Scope and Schedule managements

- Baseline WBS(included Critical path and Milestones) is structured into 5 stages to ensure accurate progress management

WBS Level **5 levels** = PBS (Physical Breakdown System) **4 levels** (Level 1~Level 4) dipole magnet, RF cavity ...) + FBS (Functional Breakdown System) **1 levels** (Level 5) design, purchase, delivery

Risk management

- At present, 8 major risks have been identified and are being monitored and managed **through "Monthly Progress Review Meeting"**

※ Delay in contract of construction company and various permissions, Safety accident, Boosting Technology, etc.

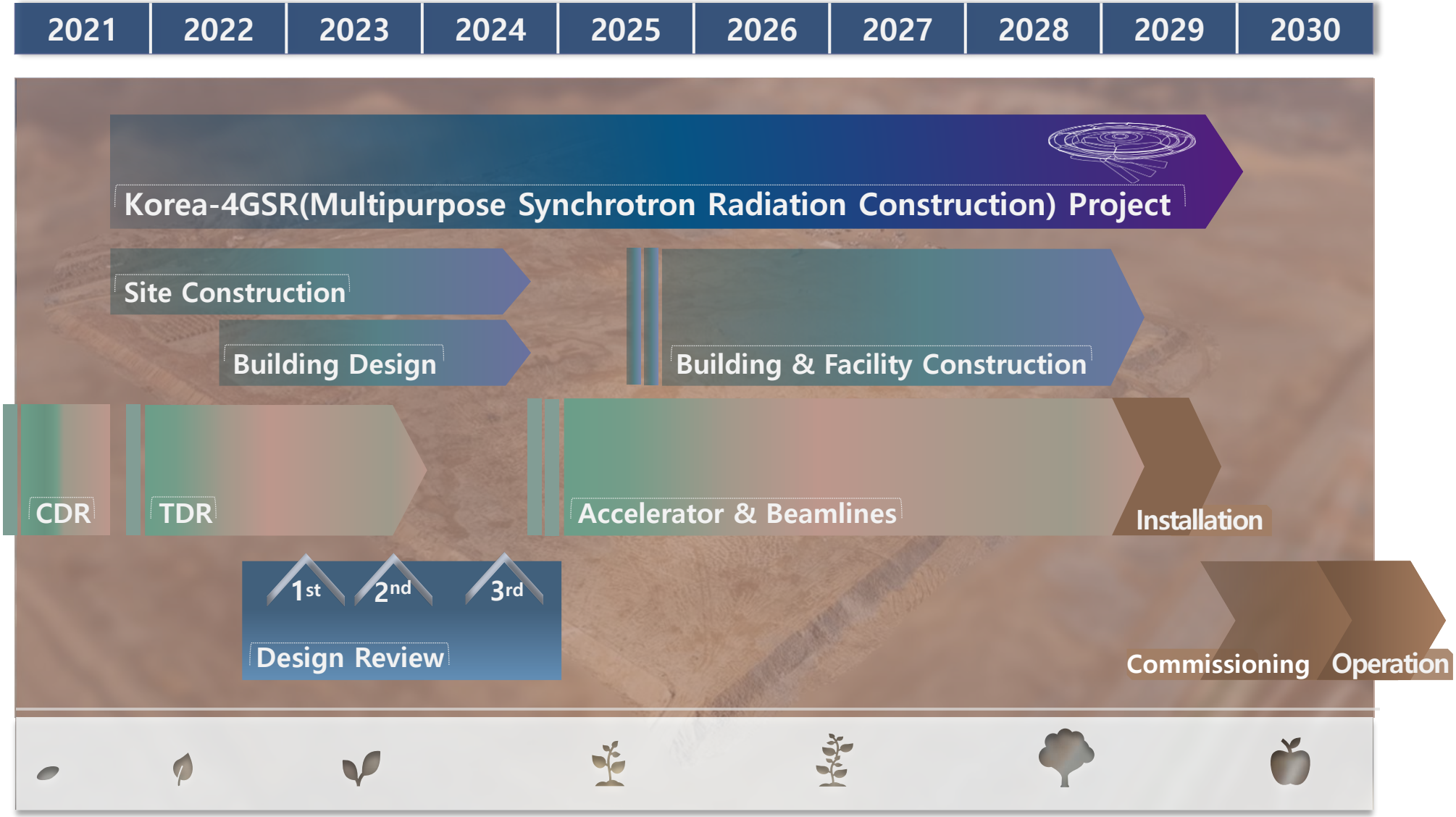
Stakeholder management

- Smooth communication and management between PAL and KBSI through "Monthly Progress Review Meeting" and "Project Coordination Council"

Change and Quality managements

- Significant changes are discussed and coordinated through Project Coordination Council
- To ensure the development of a high-performance device, Quality control is carried out and managed through "Quality Control Team" and "Technical review meeting"

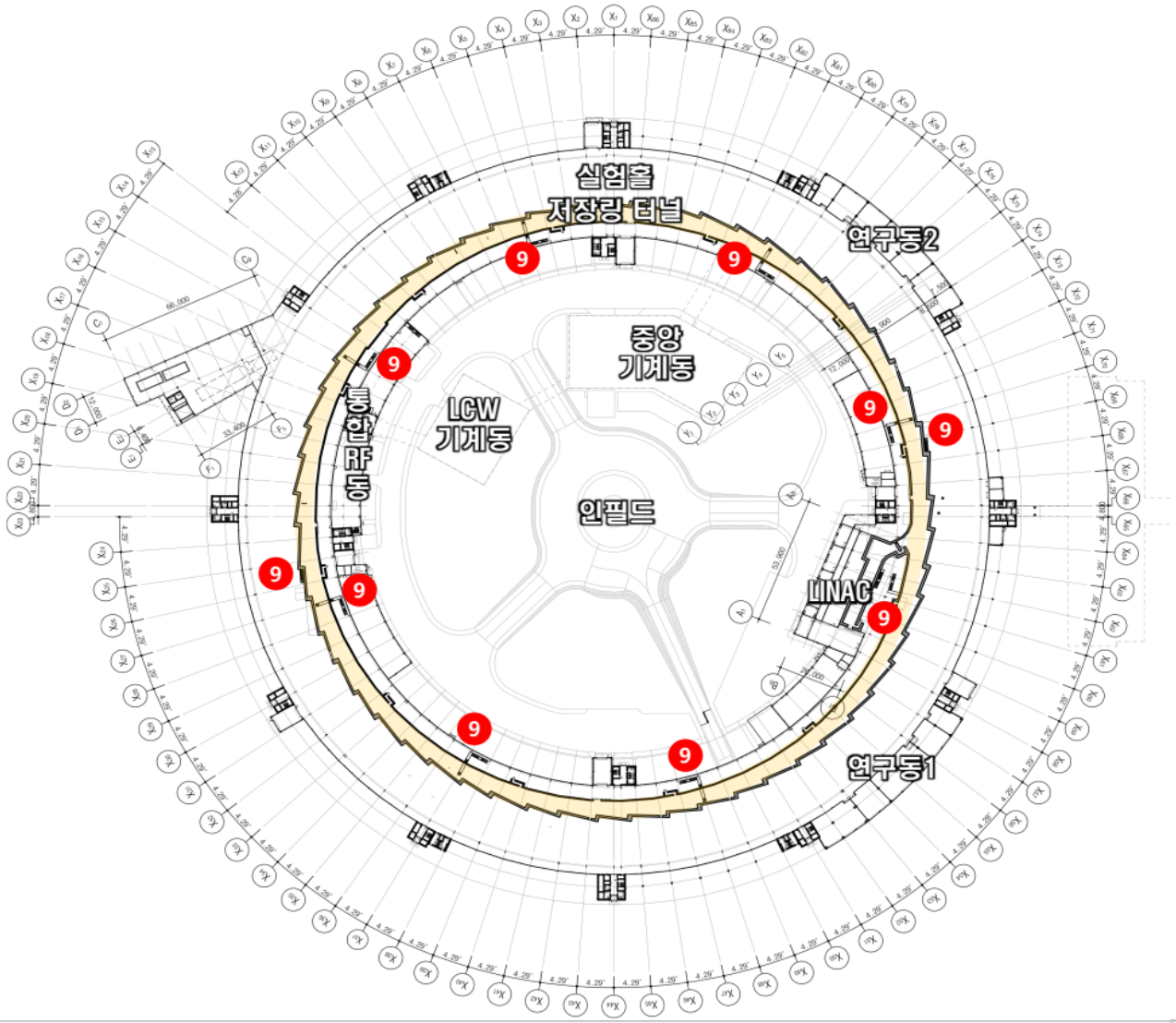
8 Project Timeline



II Site and Building

1 Site Construction

2 Building Construction

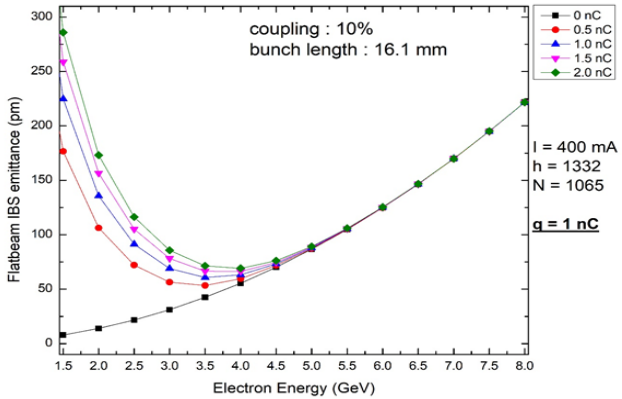


III Machine

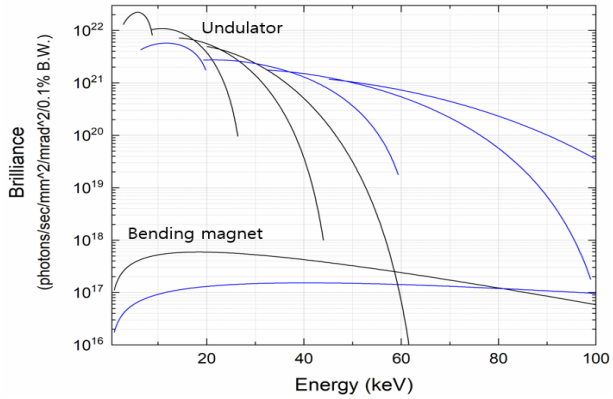
1 Initial Discussions (Energy, Lattice Type, etc)

Energy

Electron Energy (GeV)

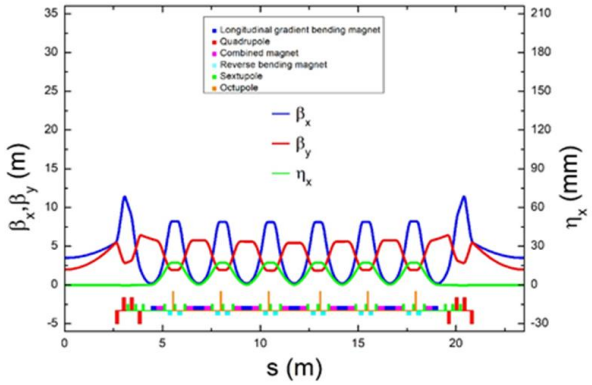


Photon Energy (keV)



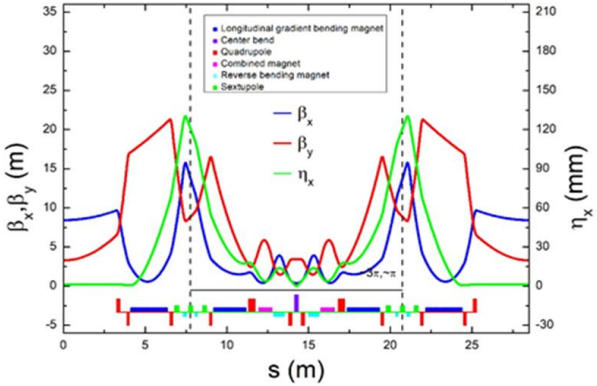
Lattice Type

Classical 7BA



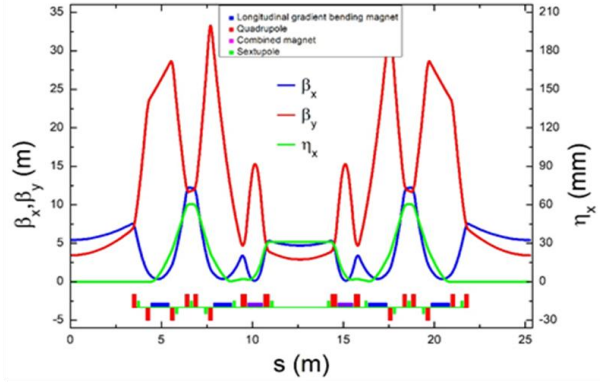
- ✓ Modular structure
- ✓ With LGB and Reverse B
- ✓ 4 GeV, 800 m and 8 pm

H7BA



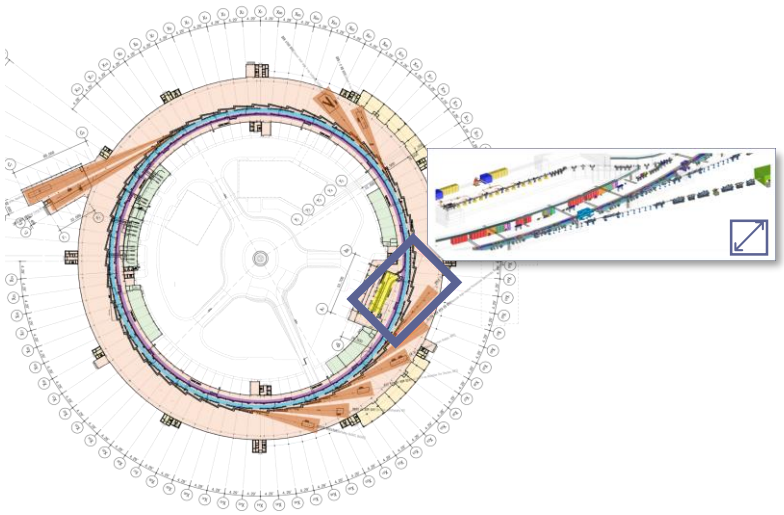
- ✓ Nonlinear cancelation
- ✓ High dispersion bump
- ✓ 4 GeV, 800 m and 58 pm

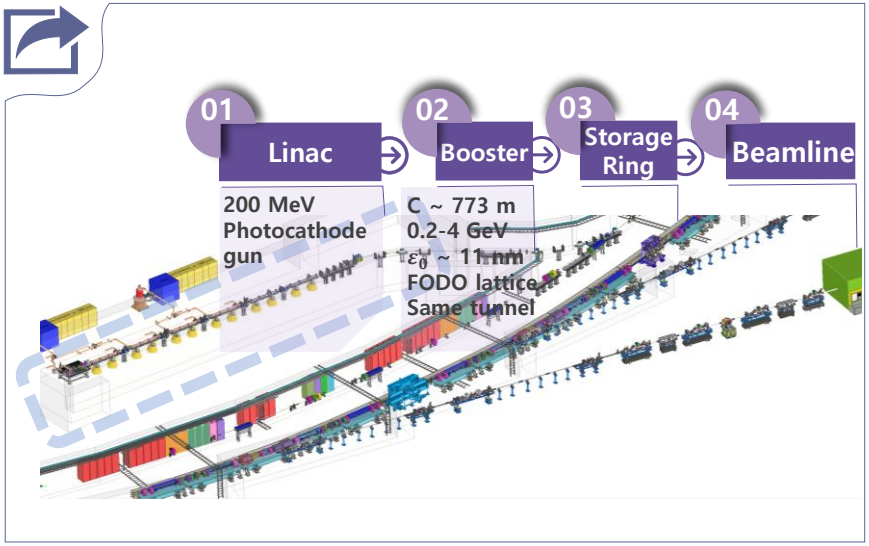
Variated 6BA



- ✓ proper to PLS-III
- ✓ Doubling number of ID
- ✓ 4 GeV, 800 m and 77 pm

2 Main Parameters





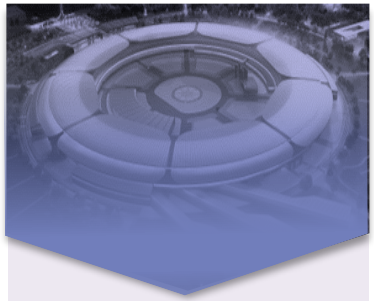
SR Ring

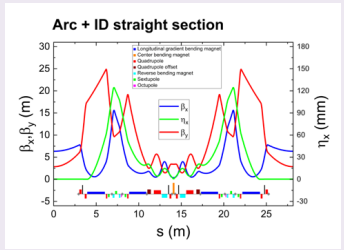
SR Ring Parameter	Vaule
Energy [GeV]	4.0
Beam current [mA]	400
Nat. Emittance [pm·rad]	61.57 (WO Ids), 52.55 (W 9 IDs)
Emittance coupling [%]	10
Energy spread	1.26E-3
Bunch Length(rms) [mm]	3.6 (without HC) / 14.4 (with HC)
Lattice	Hybrid 7 Bend Achromat
Ring Circumference [m]	799.297
Length of Straight Sections [m]	6.06
Tune (H/V)	68.18 / 23.26
(corrected) Chromaticity (H/V)	5.8 / 3.5
Momentum compaction factor	7.8 x 10^{-5}
Number of buckets	1332
Injection scheme	4 Kicker bumps, off-axis, 2Hz

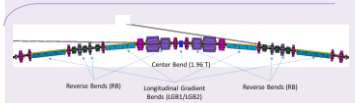
SR RF

SR RF Parameter	Vaule
RF frequency [MHz]	499.5935
RF Voltage [MV]	3.5
Energy loss per turn [KeV]	1098 (with 9 IDs: 1449)

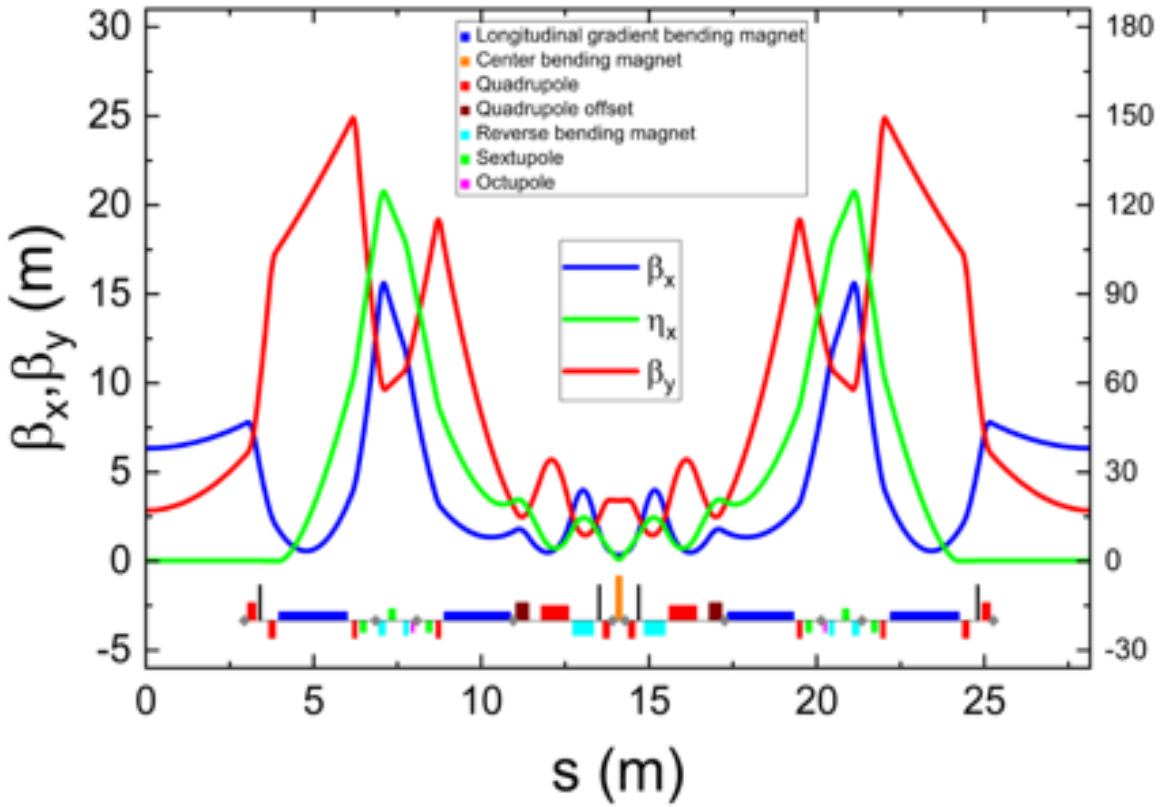
3 Accelerator





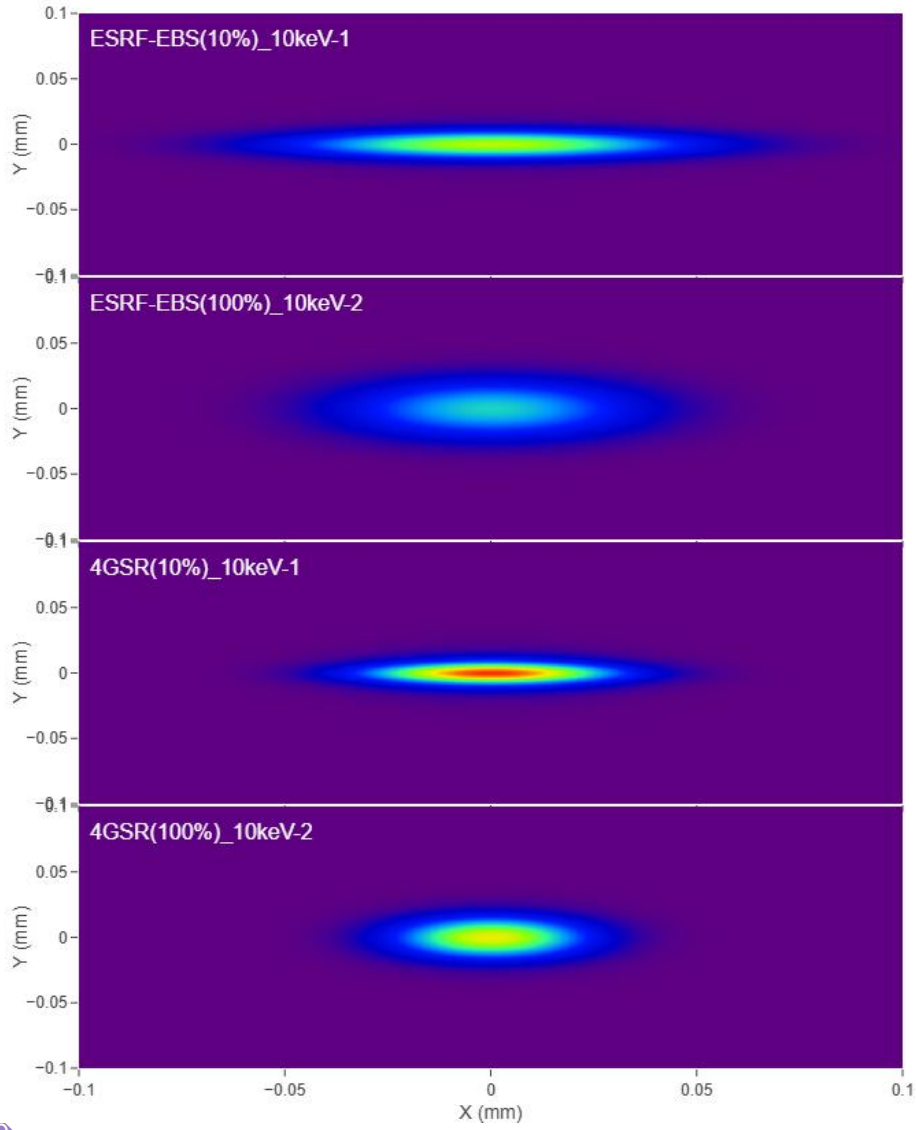


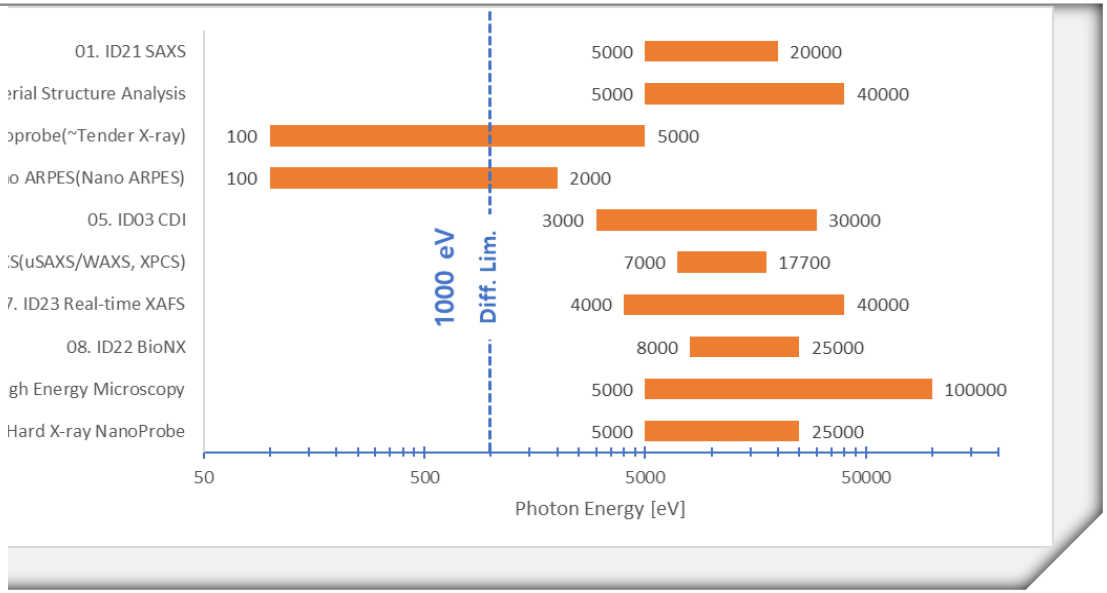
- Lattice Design
- Injection System
- SR Magnet
- Vacuum
- SR RF System



- Independent 10 RF circuit, occupying 2.5 straight sections

4 Beamline Portfolio

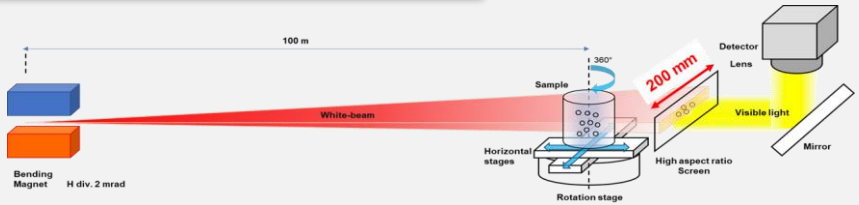




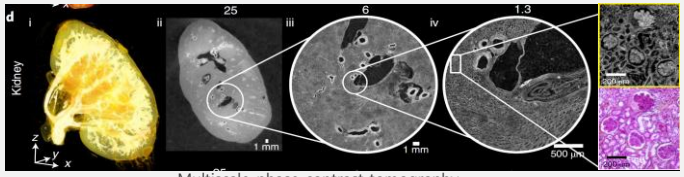
BL 05	BL 06	BL 07	BL 08	BL 09	BL 10
erent X-ray raction	Coherent Small-angle X-ray scattering	Real-time X-ray absorption Fine Structure	Bio Nano Crystallography	High Energy Microscopy	Nanoprobe
) keV	8~30 keV	4~40 keV	5~20 keV	5 ~ 100 keV	5~25 keV
ometer beam using	< 5 μm (XPCS) < 50 μm (SAXS/WAXS) △E/E < 1 × 10^{-4}	△E/E < 2 × 10^{-4}	0.7~3.5 Å	0.3~0.5 μm	△E/E < 1.5 × 10^{-4}
22	IVU20	IVU24	IVU20	Centerbend	IVU24
, CDI	SAXS/WAX, XPCS	XAFS	MX	Projection imaging	Ptychography/ XRF
iconductor, , rial Science, nistry	Material Science, Chemistry	Energy, Material Science, Earth and Environmental Science	Bio	Material Science, Energy, Bio	Semiconductor, Material Science, Earth and Environmental Science, Chemistry

5 BM10 High Energy Microscopy (BL 09)

Principle and application



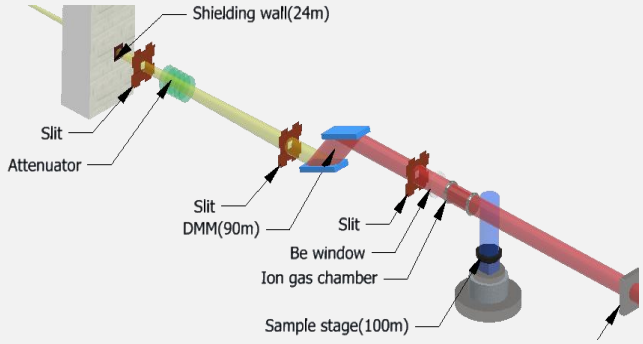
Walsh, C. L., et al. (2021). Nature methods, 18(12), 1532-1541



Multiscale phase contrast tomography

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

Beamline layout



Feature of Beamline

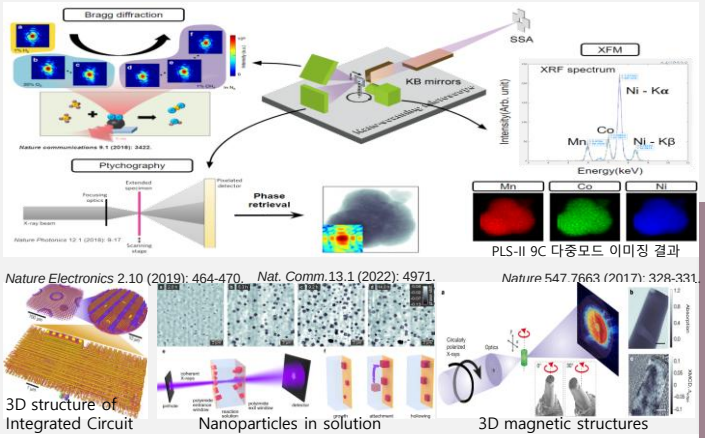
- The high energy microscope beamline is based on projection image utilizing high-energy X-ray beams above 100 keV and a long beamline of over 100 meters.
- The bending magnet illuminates the sample at a distance of 100 m with a beam of 200 mm width and 28 mm height, and acquires a high-quality projection 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.

Specification

Photon Source	Bending Magnet
Energy Range	5 ~ 100 keV (optional: 5~40 keV)
Beam size (μm²) H × V, FWHM	200 mm x 28 mm @ 100 m
Long Beamline	121 m
Spatial resolution	0.5 um
Max sample weight	100 kg

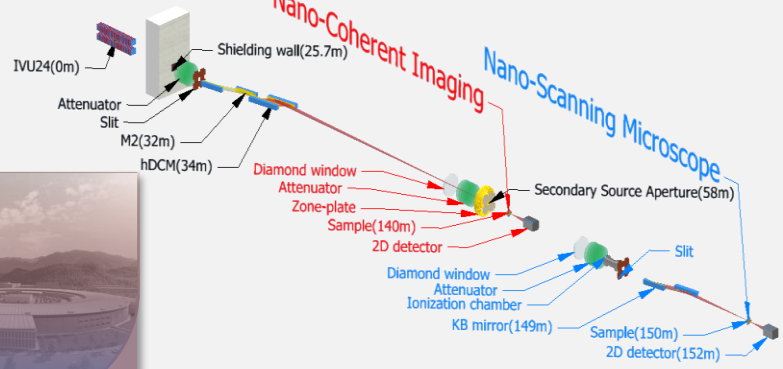
6 ID10 Hard X-ray NanoProbe (BL 10)

Principle and application



3D nanoscale quantitative analysis of complex systems

Beamline layout



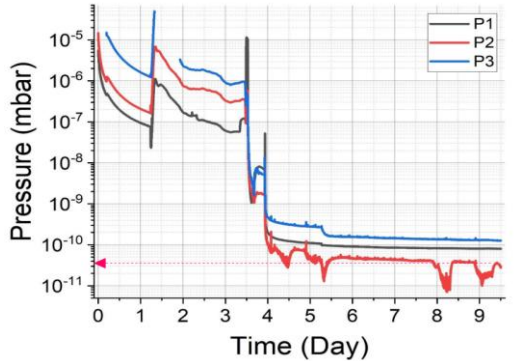
Feature of Beamline

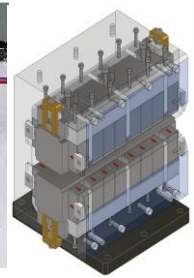
- Provides high-resolution imaging over a wide area and simultaneous elemental mapping through multimodal analysis using scanning diffraction imaging and X-ray fluorescence microscopy.
- Aims to track reactions and defect growth in systems like batteries and catalysts, enabling quantitative nanoscale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

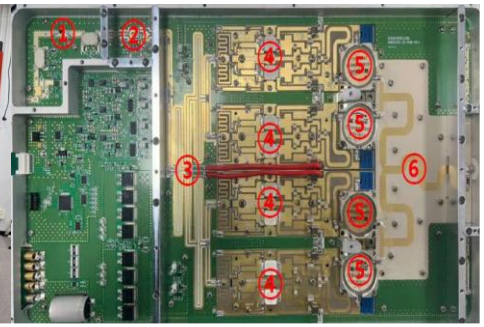
Specification

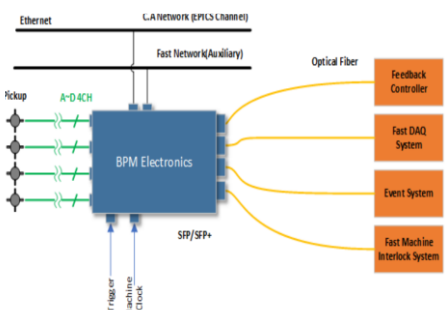
Photon Source	In Vacuum Undulator 24 (3 m)
Energy Range(mainly)	5 ~ 25 keV (8 ~ 10)
Energy resolution	< 2 x 10^{-4}
Beam flux (ph/s)	10^{9} ~ 10^{12}
Beam size (μm²) **H × V, FWHM**	50 nm x 50 nm
Spatial resolution	< 50 nm (Scanning) < 10 nm (Imaging)

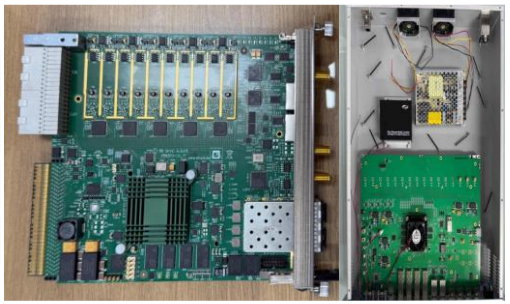
7 Highlights at Current Stage











IV Plan and Summary

1 Ongoing Work and Plan

Next stage of project (Construction phase)

- Start of main construction and machine development

Beamline

- Detailed discussions on technology and scientific application are ongoing

(There have been many public hearings for users, and technical discussions will continue further)

Reinforcement of topics requiring improvement

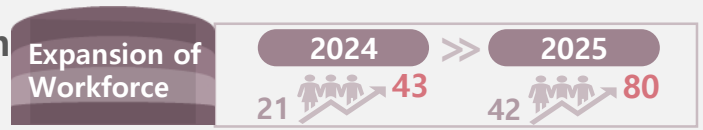
- Ultra-stable beam
- Photon beam based diagnostics (Ground motion, ID, etc. issues)
- Reinforcement of radiation source for 2nd phase (HTS 3PW, HTS Wiggler, etc)
- Data management and service software system
- Enable time-resolved experiments
- Flagship beamlines and cutting edgy science program

Machine name

- Temporary use of name : Korea-4GSR
- Before starting construction, the name of the machine will be decided through a public contest

Strengthening organization

- Expansion of workforce after organizational reform



2 Expansion of Workforce

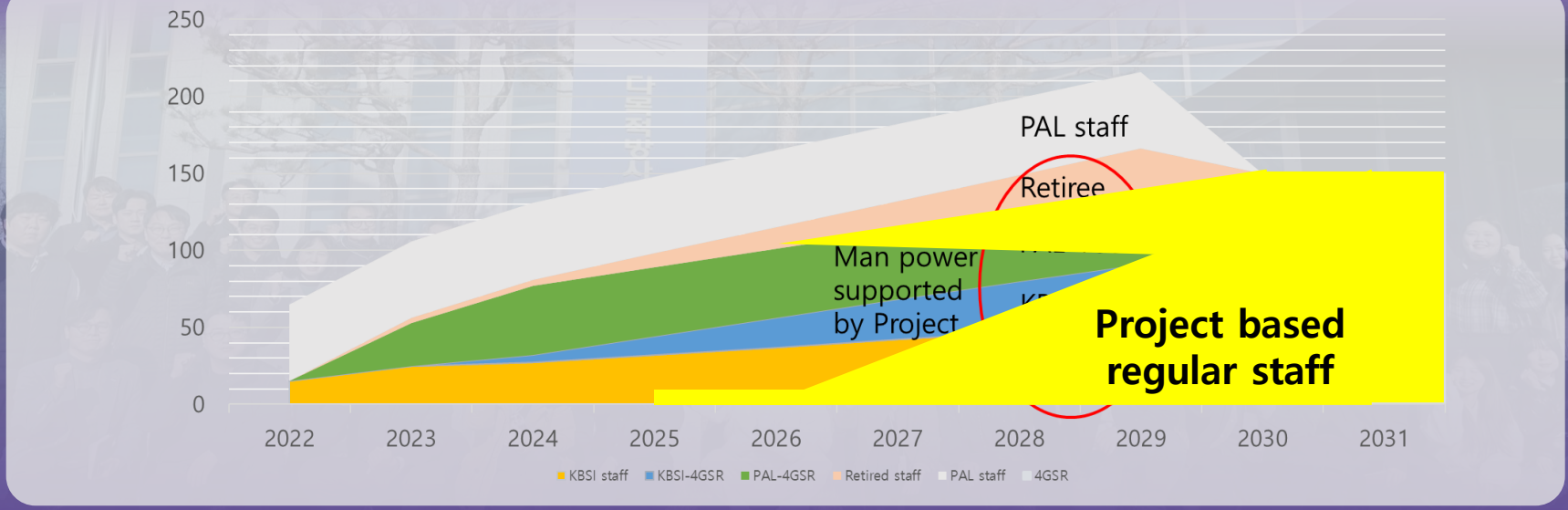
Regular Staff

- Start to secure project-based regular staff (7 in 2025, 35 in 2026, ...)

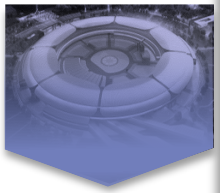
Manpower in operation

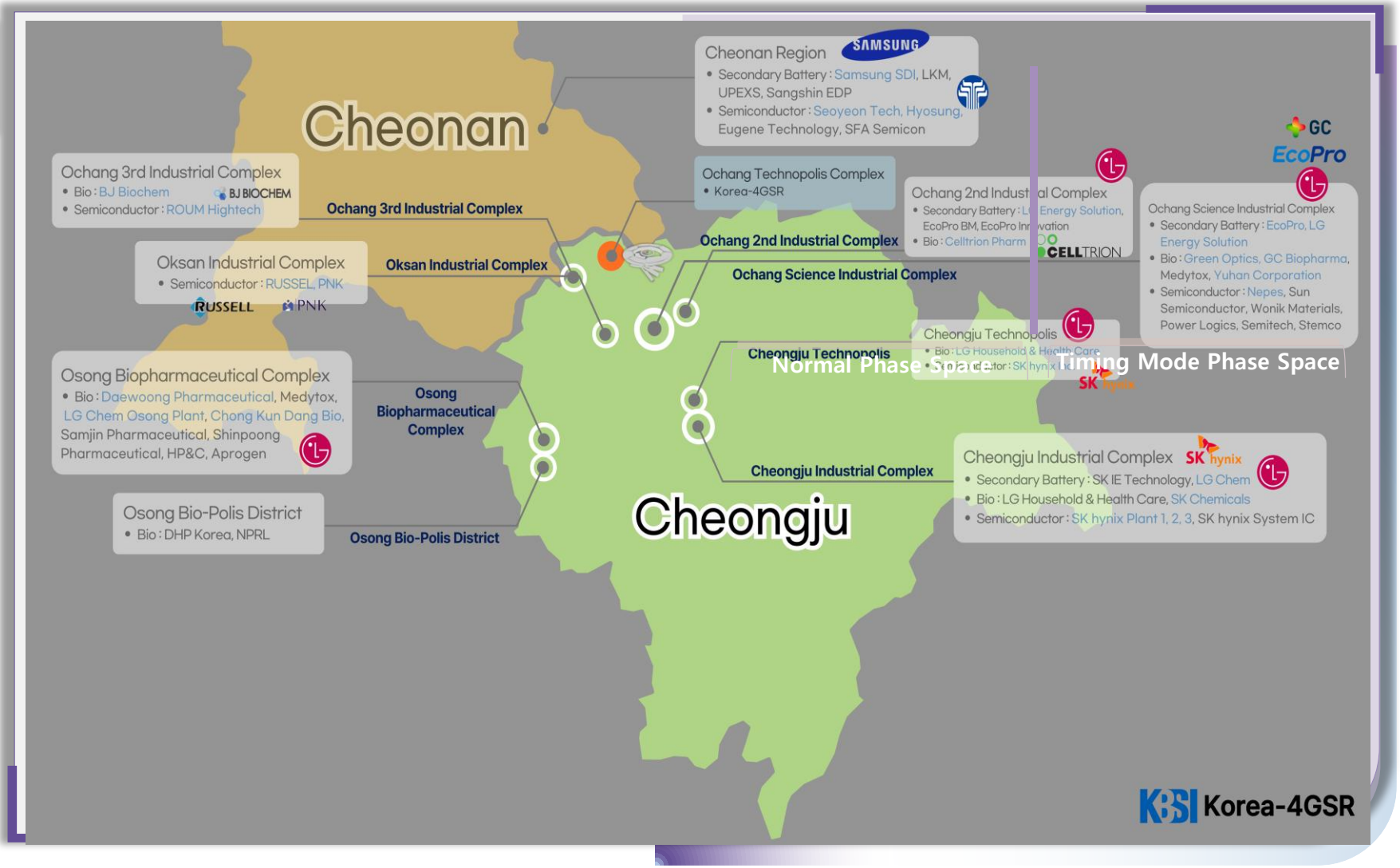
- Plan to increase 150 staffs (in an initial plan) to 185 staffs

Staff

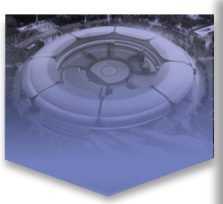


3 R&Ds and Industry Support





4 International Collaboration



- **APS-U, ESRF-EBS, SLS-II and SIRIUS**
  - Technical advisory
- **ALBA, SOLEIL, PETRA-III and NSLS-II**
  - Technical advisory
- **MAX-IV**
  - Institutional MOU
  - Overall exchange
- **Nano Terasu**
  - Industrial applications
- **Regional collaboration**
  - Close collaboration among 3GSRs and 4GSRs in Asia region
  - Technology and manpower exchange

5 Science Discussions for Korea-4GSR: Workshop and SAG

What is demands for the science after 2030?

- Experiment and sample
- Specification

What is distinguishable from existing beamline?

- PLS-II & other 3GSR
- Between BLs in K-4GSR

Competitive Differentiation

What is advantage and benefit from 4GSR?

- Experimental efficiency
- Beyond the current

How to compensate present demand and science program?

- Science community

6 This Workshop

Program Table

6/25 (WED.)

Time	Presentation	Speaker
11:00~13:00	Registration	
13:00~13:40	Opening Ceremony · Welcome Address : Sung-Kwang Yang (President of Korea Basic Science Institute) · Congratulatory address : Jaebong Song (Member of the National Assembly) Taek Ryeol Jeong (Director-General of Nuclear future energy, convergence and public mission R&D policy bureau, Ministry of Science and ICT) Soomin Kim (Vice Governor for Political Affairs, Chungcheongbuk-do) Byungdae Shin (Vice Major of Cheongju City) Photo Time	
13:40~13:50	Intermission	
13:50~14:00	Opening Remark (KBSI, PAL)	
Session 1	Construction Projects of 4th Generation Synchrotron Chair : Moses Chung (POSTECH)	
14:00~14:50	Current Status and Future Plans of Korea-4GSR	Seunghwan Shin (KBSI)
14:50~15:40	Update on HEPS Progress	Ping He (HEPS, IHEP)
15:40~16:00	Coffee Break	
Session 2	Upgrade to 4th Gen. Synchrotron and Future Science Chair : Hyunjung Kim (Sogang University)	
16:00~16:50	Advanced Photon Source Upgrade: Commissioning, Initial Science, and Future Outlook	Jonathan C Lang (APS, ANL)
16:50~17:40	From SPring-8 to SPring-8-II	Makina Yabashi (SPring-8, RIKEN)
17:40~18:30	Closing	
18:30~	Welcome Reception	invited attendee

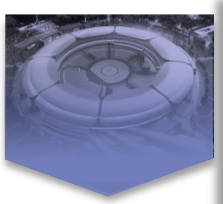
6/26 (THUR.)

Time	Presentation	Speaker
Session 3	X-ray Imaging and Spectroscopy for Applied Science Chair : Kyung-Wan Nam (Dongguk University)	
09:30~10:10	Multi-resolution tomography on large samples, the performances of the ESRF-EBS beamline BM18	Paul Tafforeau (ESRF)
10:10~10:50	Lithium-ion Battery Dynamics: From Single Particles to Cells	Jongwoo Lim (Seoul National University)
10:50~11:30	Advancements in Spectroscopy Techniques at the APS-U Beamline S-25	Shelly Diane Kelly (APS, ANL)
11:30~13:00	Lunch Break	
Session 4	X-ray Crystallography for Bio-Science Chair : Sun-Shin Cha (Ewha Womans University)	
13:00~13:40	Structural basis for the recognition of type-2 N-degron substrate by PRT1 E3 ubiquitin ligase	Hyun Kyu Song (Korea University)
13:40~14:20	Advancing macromolecular structure determination with microsecond X-ray pulses at a 4th generation synchrotron	Daniele de Sanctis (ESRF)
14:20~14:40	· Break Time	
Session 5	Soft X-ray Spectroscopy for Material Science Chair : Ki-Jeong Kim (PAL)	
14:40~15:20	Recent advances in ambient pressure XPS	Bongjin Simon Mun (GIST)
15:20~16:00	Advanced ARPES program and future science in ALS	Eli Rotenberg (ALS, LBNL)
16:00~16:20	Coffee Break	
Session 6	Advanced Coherent X-ray Scattering Chair : Seo Hyoung Chang (Chung-Ang University)	
16:20~17:00	Coherence application beamline P10 and the future upgrade to CAB	Wojciech Roseker (PETRA-III, DESY)
17:00~17:40	Seeing Disorder through Coherence: Extreme Light on Complex Matter	Changyong Song (POSTECH)
18:30~	Dinner	

6/27 (FRI.)

Time	Presentation	Speaker
Session 7	Status of Phase-I 10 Beamline Projects Chair : Changyong Song (POSTECH)	
09:00~09:40	Probing Materials with Advanced X-ray Spectroscopy	In-Hui Hwang (K-4GSR Project)
09:40~10:20	Nanoscale Probes in the Soft X-ray Regime: nanoARPES and Soft X-ray nanoprobe	Sae Hee Ryu (K-4GSR Project)
10:20~10:30	Break Time	
10:30~11:10	Construction and utilization of Korea-4GSR's life science and imaging beamline	Mi-Jeong Kwak (K-4GSR Project)
11:10~11:50	Design Strategies and Progress of Coherence Beamlines at Korea-4GSR for Advanced Science	Jaeyong Shin (K-4GSR Project)
11:50~12:10	Closing Remark / Photo	
12:10~	Site Tour (invited attendee)	
특별 세션	방사광가속기와 산학연 혁신 역량 강화 Satellite Session : Strengthening of Industry-Academic Innovation using Synchrotron 충북과학기술혁신원 (Chungbuk Innovation Institute of Science & Technology)	
13:20~14:00	다목적 방사광가속기 산학연 혁신협의회 발전 방향 Development Direction of Industry-Academic Innovation Council for Multi-purpose Synchrotron Radiation Facility	Dong-Hyun Kim (Chungbuk National University)
14:00~15:00	한국 4GSR의 개요 및 진행 상황 Overview & Progress of Korea 4GSR	Hyung-Joong Yun (KBSI)
15:00~15:20	휴식시간 (Coffee Break)	
15:20~16:00	전문가 매칭 기업 컨설팅 Company Consulting and Expert matching	
16:00~	기념촬영 및 폐회 Closing Remark and Photo Time	

7 Summary



- We updated the status of Korea-4GSR
- This project entered stable phase from a budget and schedule perspective
  - The final design review had been completed and the budget and schedule adjustments had been confirmed by the government
- We shared what is going on

01	02	03	04
Next stage of project (construction and development)	Reinforcement of topics requiring improvement	Strengthening organization Deciding machine name	Collaboration and performing R&Ds

- In this workshop, let's enjoy the latest trends in research using synchrotron radiation and we welcome your valuable advice on our initial 10 BLs.

Thank You