Congratulations for 70th Anniversary

of

Turkish Physical Society

and

Korean Physical Society

We enjoyed 2002 World Cup Semi-final Match

(Turkiye 3 : 2 Korea)

And

Korea thanks Turkish Army for one of 16-UN Forces

during Korean Conflict in 1950-1953

Brief Facts about Korea

People & Language: Korean (~4,500 yrs in the area)
Area (South)**:** ~100,000 km^2 (~38,000 sq. mi.)
Population (South)**:** 52 million

Recent History:

1945: Divided into North and South
1950~1953: Korean Conflict
1960~1970: Modernization (Migration to cities)
1970~1980: Industrialization (Heavy Industries)
1990~2022: High-tech oriented

Leading Industries:

Electronics, Automobile, Ship-building,
Steel, Chemicals, Construction

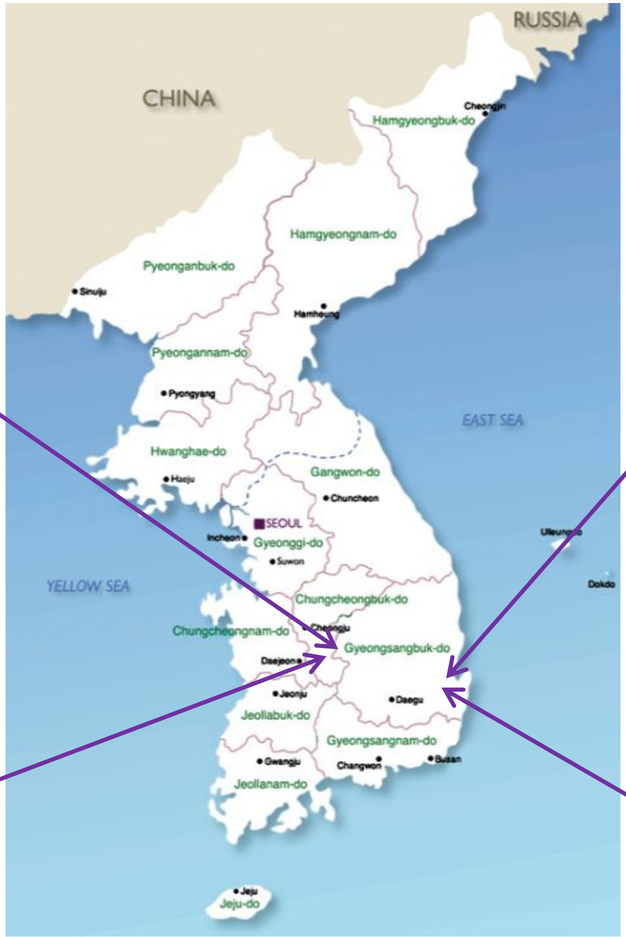
Economy: GDP = 1.8 T$ and 35.4 k$/capita in 2021

Religion: Christian (~30%), Buddhism (~30%)
Education: > 80% high-school seniors go to college

Accelerator Facilities in Korea (2022)

4GSR Project (KPS)
(Under construction)

Rare Isotope Science Project (RISP)
(Under construction)



PAL-XFEL (10.0 GeV) and
PLS-II (3.0 GeV Light Source)

KOMAC (100-MeV Proton Linac)

Status and Prospects
of
Pohang Accelerator Laboratory (PAL)

UPHUK-VIII
Bodrum, Turkiye

September 5-7, 2022

Won Namkung

PAL, POSTECH

Aerial View of PAL

Pohang Accelerator Laboratory Overview

- ***POSTECH***, a newly established university, proposed to construct a synchrotron light source on its campus in 1988

- ***PLS is a 3rd generation synchrotron radiation source***:

  - 2 GeV injector linac and storage ring with upgrade option to 2.5-GeV
  - Construction Project: April 1988 ~ December 1994
  - Funded by POSCO (60%) & Government (40%)

- ***Upgraded to 3.0 GeV in 2011 (PLS-II)***
- ***PAL-XFEL (X-ray Free Electron Laser) was constructed in 2015***

  - World 3rd after SLAC (US) and SACLA (Japan)

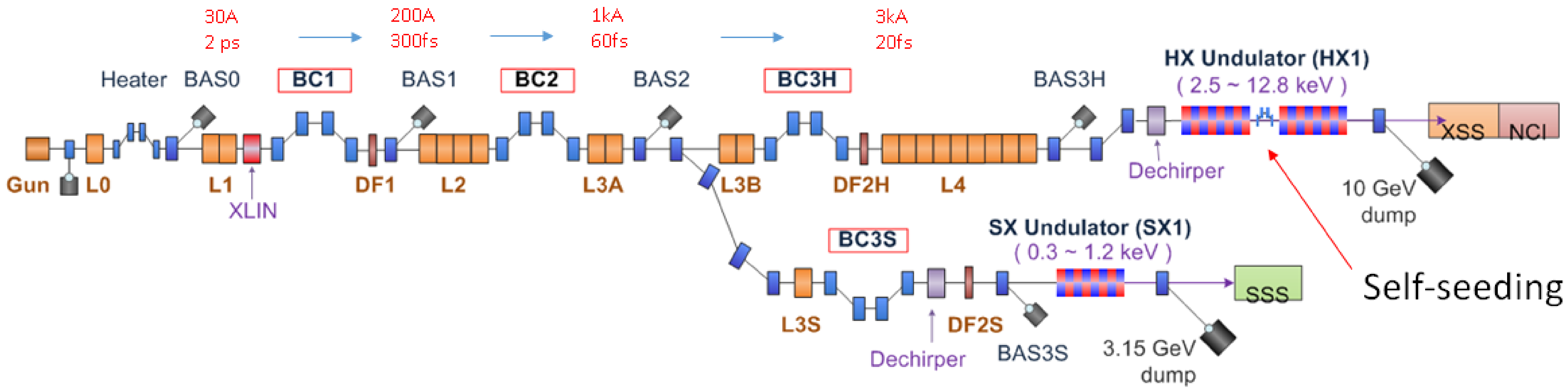
- PAL is donated to Government in 2018
- ***KPS Project (4.0 GeV, 4GSR) is started with KBSI in Chung-ju (2021-2027)***

PAL-XFEL

Initial proposal was to use existing PLS linac to be a leading group member in 2003

Revised proposal in 2010 for 10 GeV XFEL

PAL-XFEL Layout and Parameters

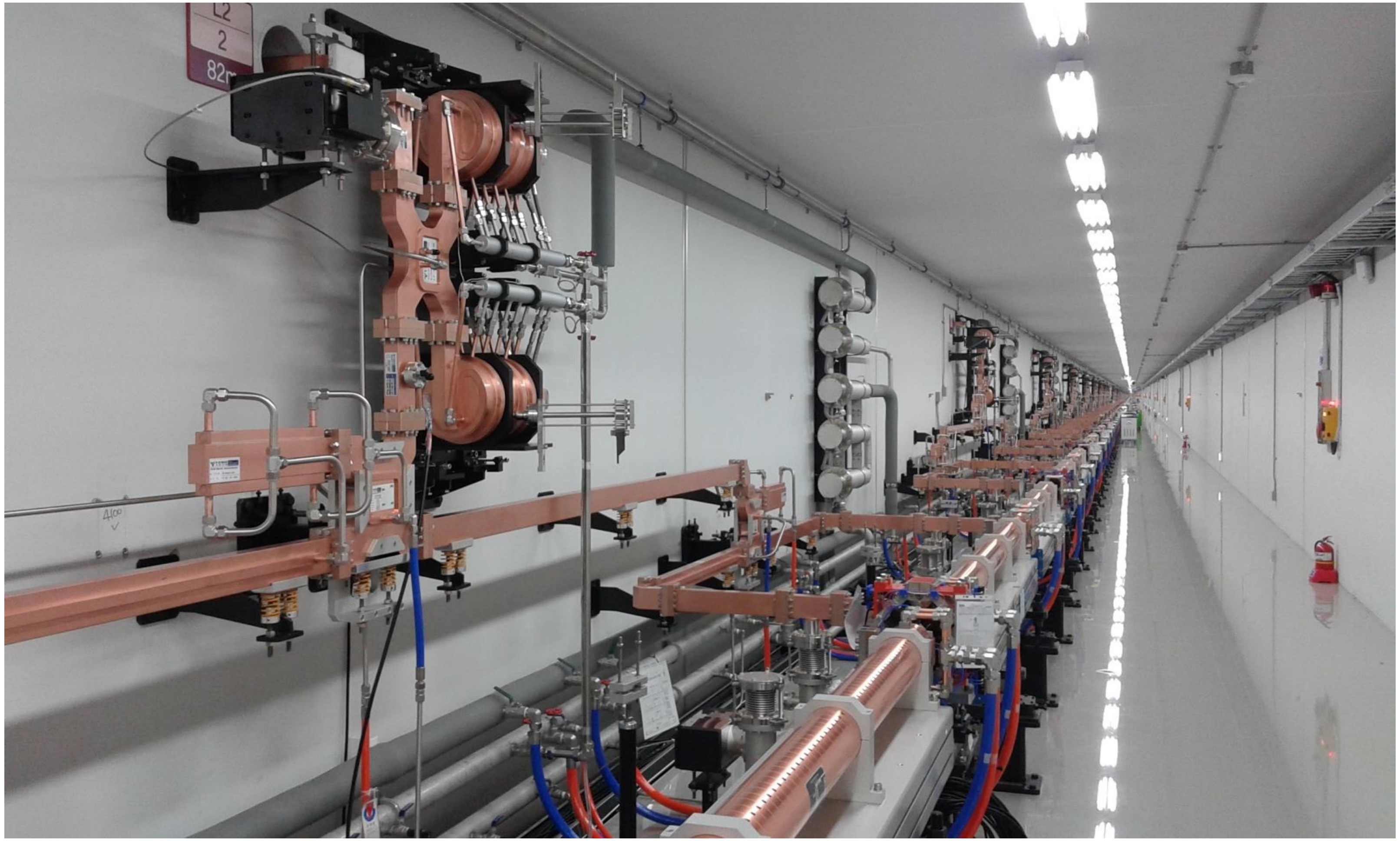


Main parameters

e^- Energy	10 GeV
e^- Bunch charge	20-200 pC
Slice emittance	< 0.4 mm mrad
Repetition rate	60 Hz
Bunch length	5 fs – 50 fs
Peak current	3 kA
SX line switching	Kicker Magnet

Undulator Line	HX	SX
Photon energy [keV]	2.4 ~ 15	0.28 ~ 1.0
Beam Energy [GeV]	4 ~ 11	3.0
Wavelength Tuning	Energy	Gap
Undulator Type	Planar	Planar
Undulator Period / Gap [mm]	26 / 8.3	35 / 9.0

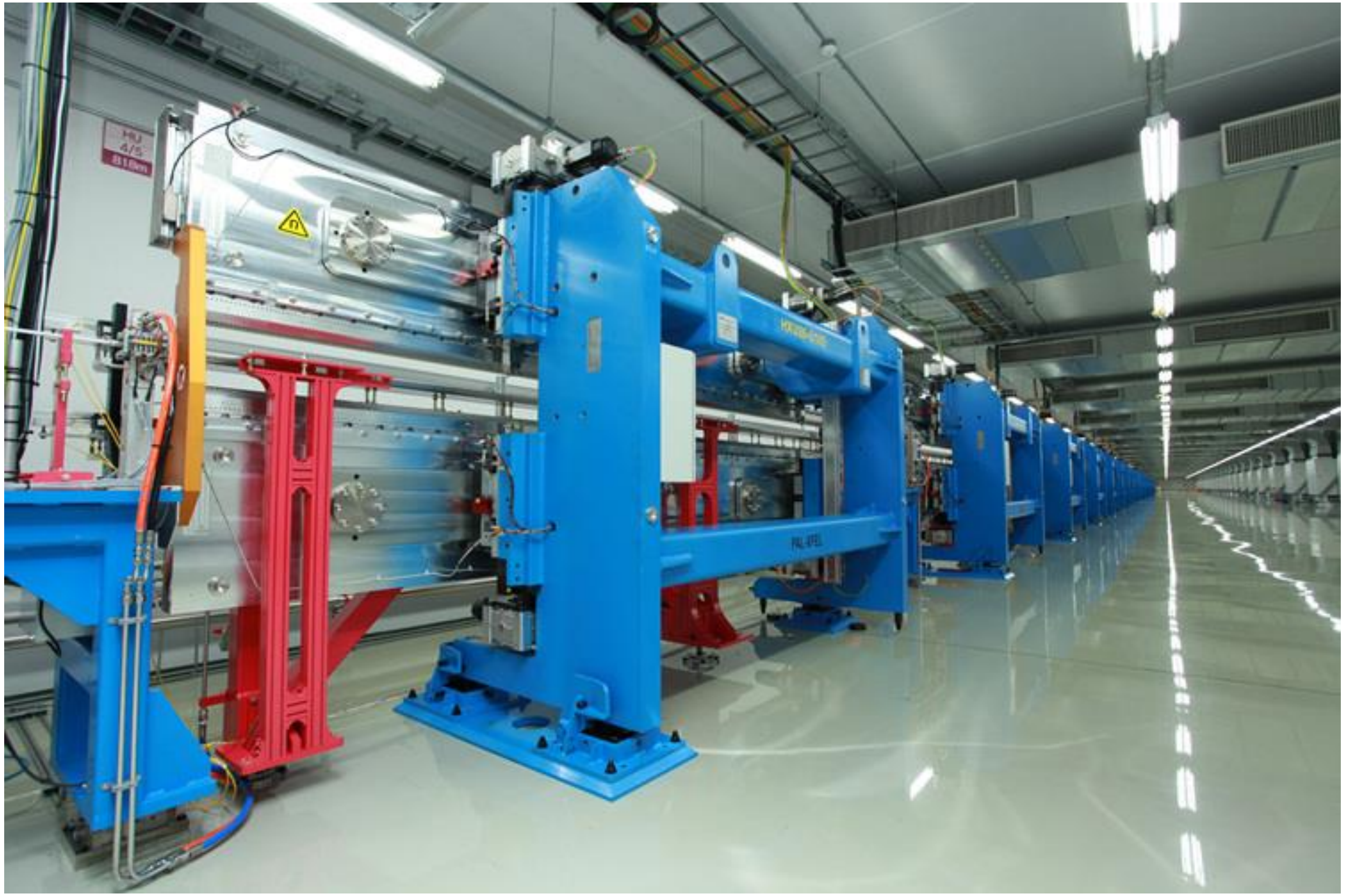
Linac Tunnel



Cross Section of Acceleration. Column

Parameter	Unit	Value
Energy	GeV	10
Charge	pC	200
No. of SLED		42
No. of Acc. Column		173

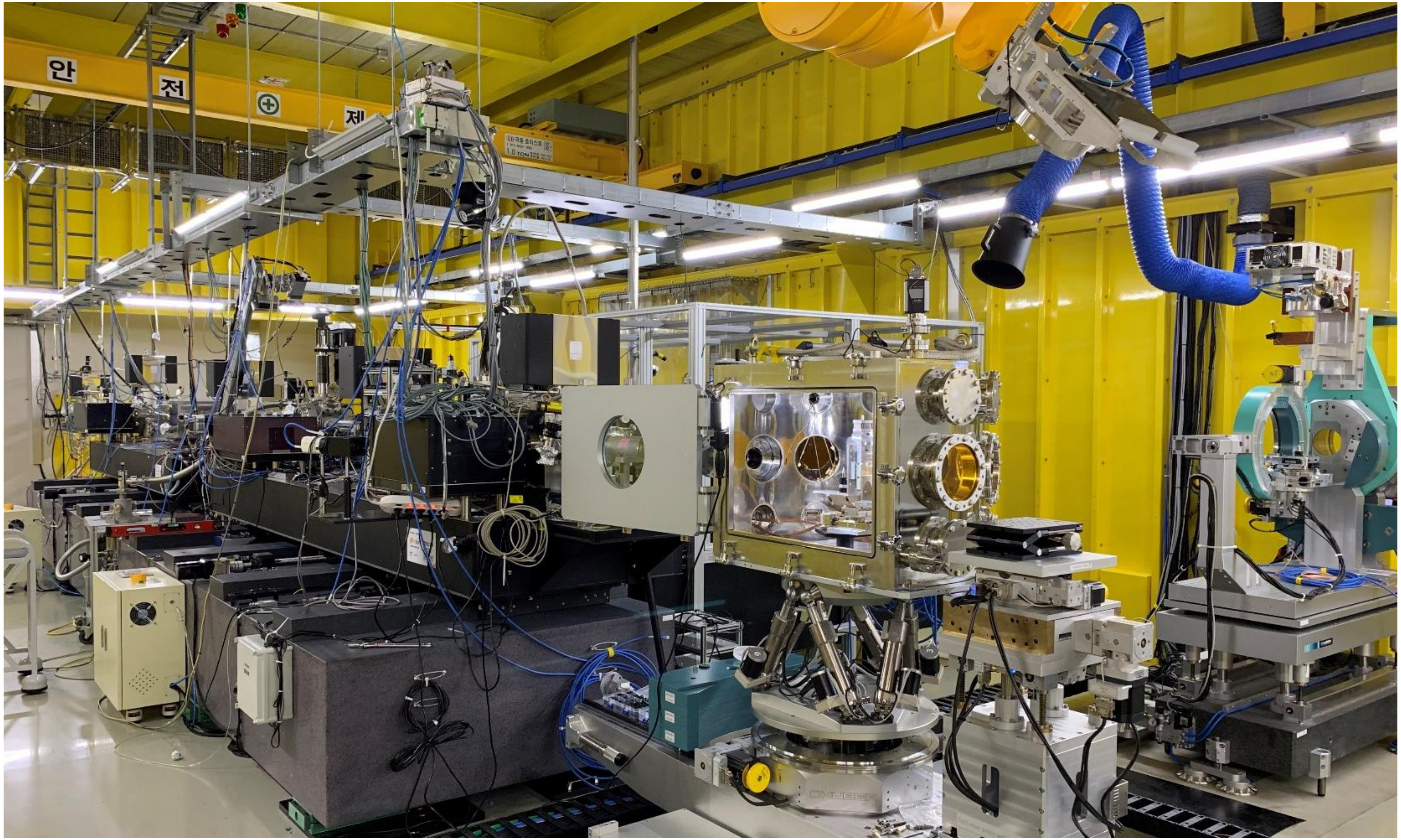
Undulator Hall



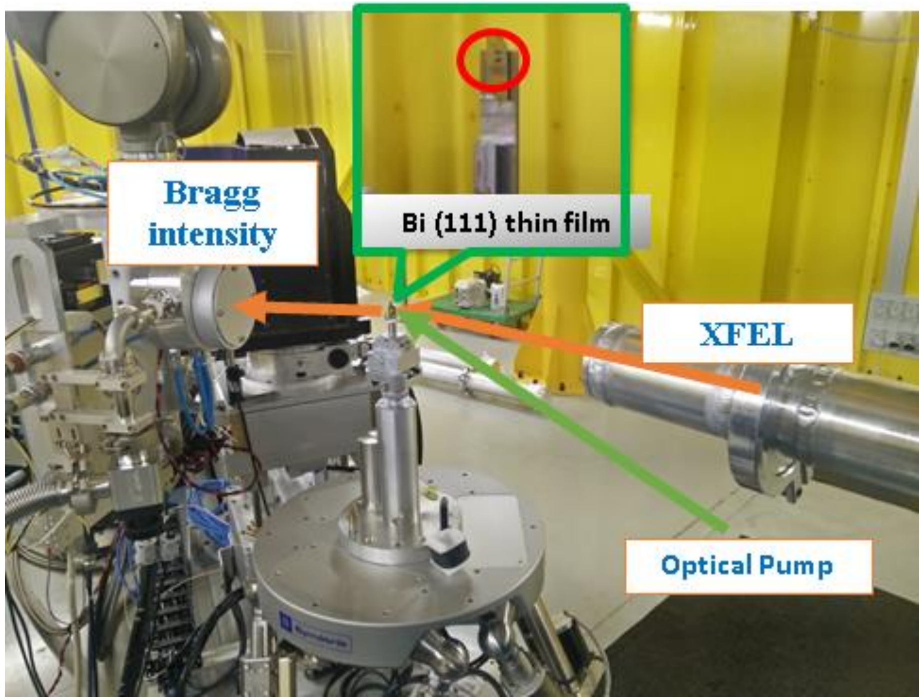
Parameter	Unit	Value
No. of Undulator		21
Length	m	5
Period	mm	26.0
Gap	mm	8.3
Wavelength	nm	0.1
Magnetic field	Tesla	0.8124
K		1.9727

Hard X-ray Experiment Hutches

Hard X-ray Experiment Station

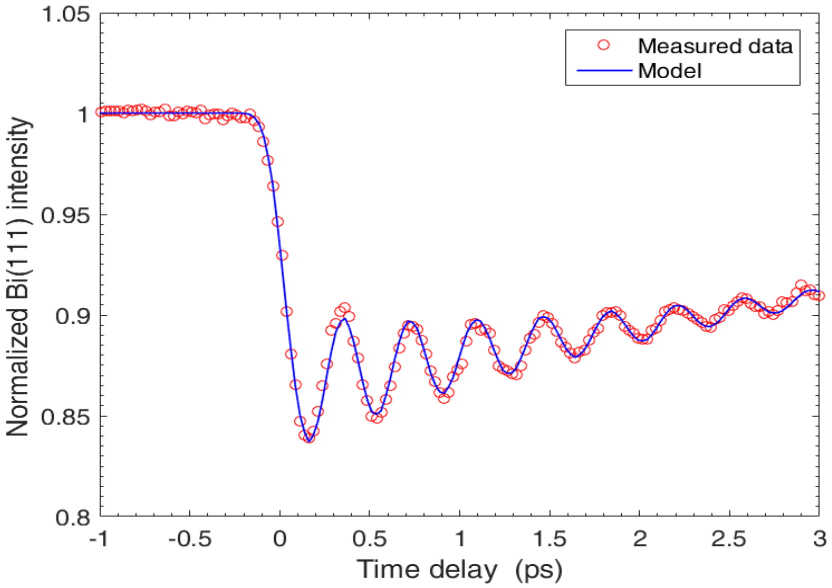


Hard X-ray FEL with Femtosecond Timing Jitter

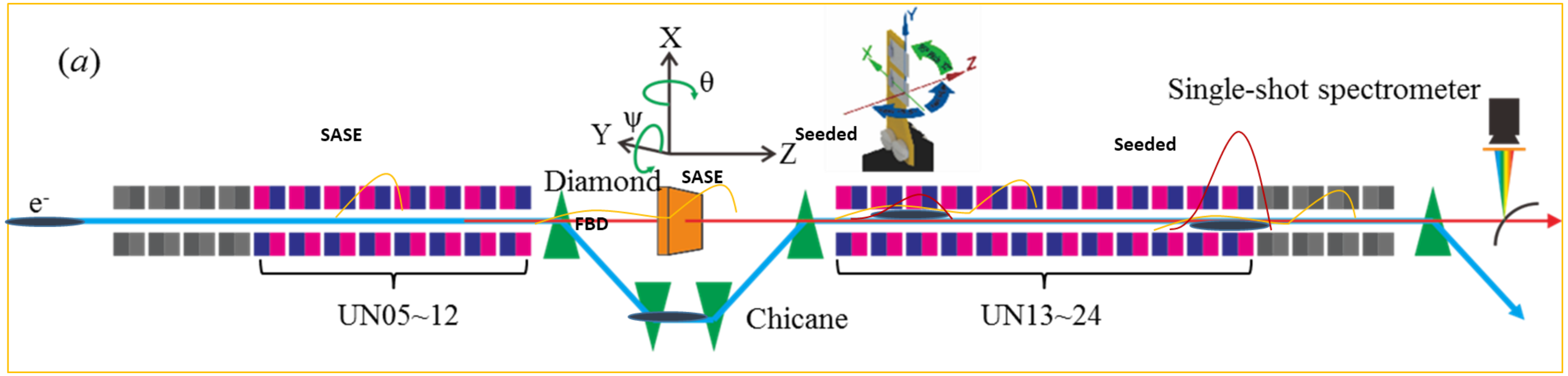


Bi(111) thin film (50 nm) on GaSb(111)/Si(111)
X-ray: 6 keV
X-ray size: ~ 60 x 60 um^2
Laser: 800 nm, 100 fs
Detector: MPCCD 0.5M

- **No timing jitter correction**
- averaged by 50 trials of the time delay scan and normalized by GaSb(111) Bragg peak intensity
- **Only slow time-drift correction**
- **Vibration Frequency : 2.7 THz**
- Instrument Response: 137 fs (FWHM)



Hard X-ray self seeding



- Ec = 9.7 keV
- SASE bandwidth (FWHM) = 27 eV
- Self-seeding bandwidth (FWHM) = 0.22 eV
- Averaged pulse energy: ~850 μJ
- FEL Pulse duration = ~ 20 fs

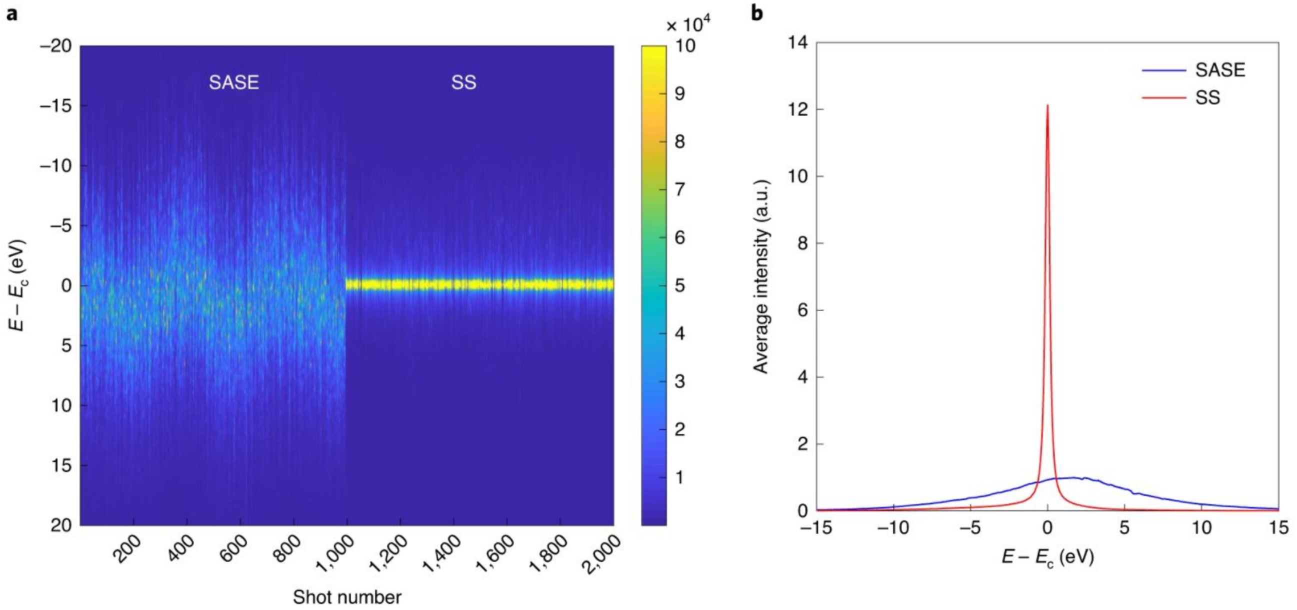
nature photonics
ARTICLES
https://doi.org/10.1038/s41566-021-00777-z
Check for updates

High-brightness self-seeded X-ray free-electron laser covering the 3.5 keV to 14.6 keV range

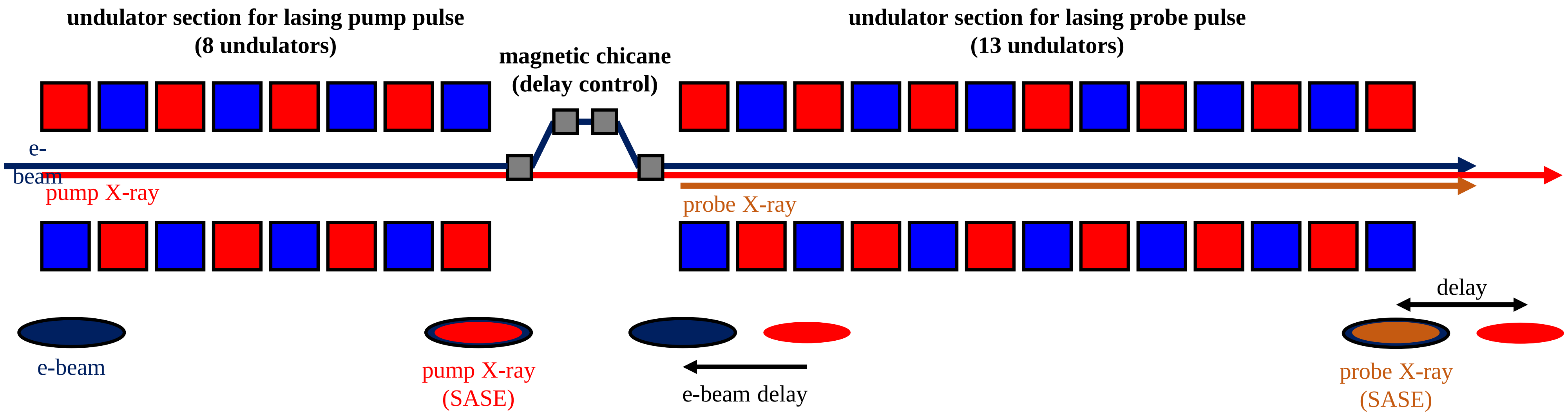
Inhyuk Nam[1,4], Chang-Ki Min[1,4], Bonggi Oh[1,4], Gyujin Kim[1], Donghyun Na[1], Young Jin Suh[1], Haeryong Yang[1], Myung Hoon Cho[1], Changbum Kim[1], Min-Jae Kim[1], Chi Hyun Shim[1], Jun Ho Ko[1], Hoon Heo[1], Jaehyun Park[1], Jangwoo Kim[1], Sehan Park[1], Gisu Park[1], Seonghan Kim[1], Sae Hwan Chun[1], HyoJung Hyun[1], Jae Hyuk Lee[1], Kyung Sook Kim[1], Intae Eom[1], Seungyu Rah[1], Deming Shu[2], Kwang-Je Kim[2], Sergey Terentyev[3], Vladimir Blank[3], Yuri Shvyd'ko[2]✉, Sang Jae Lee[1]✉ and Heung-Sik Kang[1]✉

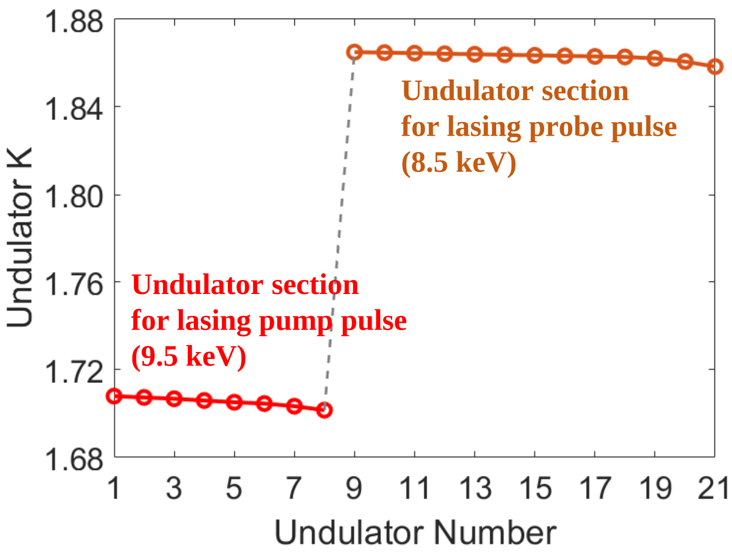
A self-seeded X-ray free-electron laser (XFEL) is a promising approach to realize bright, fully coherent free-electron laser (FEL) sources in the hard X-ray domain that have been a long-standing issue with longitudinal coherence remaining challenging. At the Pohang Accelerator Laboratory XFEL, we have demonstrated a hard X-ray self-seeded XFEL with a peak brightness of 3.2×10^{35} photons s^{-1} mm^{-2} $mrad^{-2}$ 0.1% bandwidth $(BW)^{-1}$ at 9.7 keV. The bandwidth (0.19 eV) is about 1/70 times as wide (close to the Fourier transform limit) and the peak spectral brightness is 40 times higher than in self-amplified spontaneous emission (SASE), with substantial improvements in the stability of self-seeding and noticeably suppressed pedestal effects. We could reach an excellent self-seeding performance at a photon energy of 3.5 keV (lowest) and 14.6 keV (highest) with the same stability as the 9.7 keV self-seeding. The bandwidth of the 14.6 keV seeded FEL was 0.32 eV, and the peak brightness was 1.3×10^{35} photons s^{-1} mm^{-2} $mrad^{-2}$ 0.1%BW^{-1}. We show that the use of seeded FEL pulses with higher reproducibility and a cleaner spectrum results in serial femtosecond crystallography data of superior quality compared with data collected using SASE mode.

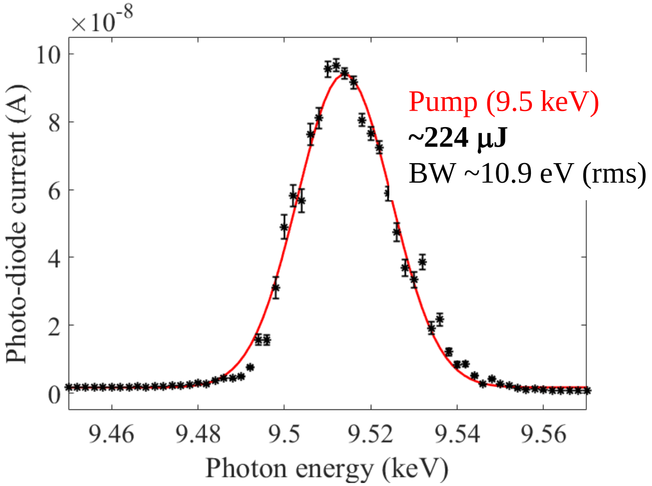
Nat. Photon. **15**, 435 (2021)

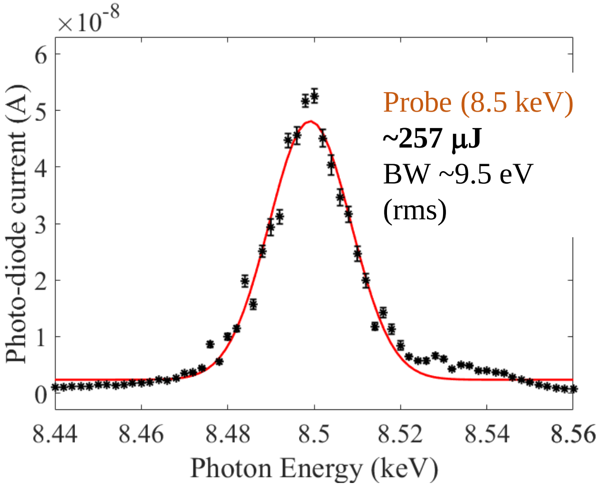


Two-color HX FEL pulse generation









Machine study results (2022. 01. 15)

PAL-XFEL Machine Performance

FEL position stability:	< 10 % of beam size
FEL power stability:	< 5 % rms
E-beam energy jitter:	< 0.015 %
E-beam arrival time jitter:	< 15 fs
FEL pulse energy:	> 3.18 mJ at 7.13 keV
FEL beam pulse duration:	20 ~ 30 fs (FWHM)
Saturated FEL:	up to 20.0 keV

- Lattice design used three bunch compressor configuration
- Machine stability is outstanding
- Self-seeding and two-color generation are very promising

PAL-XFEL Statistics

Annual Plan of Operation (Days)

	2017	2018	2019	2020	2021	2022
User Beam-time	120	140	160	170	180	190
Turn-on & Tuning	123	110	73	67	70	57
Machine Study			21	21	10	10
Maintenance	109	102	98	97	92	95

User Service

	Applied	Approved	Days of Service
2017	82	26	120
2018	84	45	140
2019	140	49	160
2020	118	51	170
2021	132	47	180
2022	131	53	190

REPORT

WATER THERMODYNAMICS

Maxima in the thermodynamic response and correlation functions of deeply supercooled water

Kyung Hwan Kim,[1]* Alexander Späh,[1]* Harshad Pathak,[1] Fivos Perakis,[1]
Daniel Mariedal
Sangsoo Kim,[3] J

RESEARCH

WATER PHASES

Experimental observation of the liquid-liquid transition in bulk supercooled water under pressure

Kyung Hwan Kim[1,2]*, Katrin Amann-Winkel[1]*, Nicolas Giovambattista[3,4], Alexander Späh[1], Fivos Perakis[1], Harshad Pathak[1], Marjorie Ladd Parada[1], Cheolhee Yang[2], Daniel Mariedahl[1], Tobias Eklund[1], Thomas. J. Lane[5,6], Seonju You[2], Sangmin Jeong[2], Matthew Weston[1], Jae Hyuk Lee[7], Intae Eom[7], Minseok Kim[7], Jaeku Park[7], Sae Hwan Chun[7], Peter H. Poole[8], Anders Nilsson[1]†

SCIENCE ADVANCES | RESEARCH ARTICLE

APPLIED SCIENCES AND ENGINEERING

Ultrafast x-ray diffraction study of melt-front dynamics in polycrystalline thin films

Tadesse A. Assefa[1]*, Yue Cao[1†], Soham Banerjee[1,2], Sungwon Kim[3], Dongjin Kim[3], Heemin Lee[4], Sunam Kim[5], Jae Hyuk Lee[5], Sang-Youn Park[5], Intae Eom[5], Jaeku Park[5], Daewoog Nam[5], Sangsoo Kim[5], Sae Hwan Chun[5], Hyojung Hyun[5], Kyung sook Kim[5], Pavol Juhas[6], Emil S. Bozin[1], Ming Lu[7], Changyong Song[4], Hyunjung Kim[3], Simon J. L. Billinge[1,2], Ian K. Robinson[1,8]*

SCIENCE ADVANCES | RESEARCH ARTICLE

MATERIALS SCIENCE

Subnanosecond phase transition dynamics in laser-shocked iron

H. Hwang[1], E. Galtier[2], H. Cynn[3], I. Eom[4], S. H. Chun[4], Y. Bang[1], G. C. Hwang[1], J. Choi[1], T. Kim[1], M. Kong[1], S. Kwon[1], K. Kang[1], H. J. Lee[2], C. Park[5], J. I. Lee[5], Yongmoon Lee[6], W. Yang[6], S.-H. Shim[7], T. Vogt[8], Sangsoo Kim[4], J. Park[4], Sunam Kim[4], D. Nam[4], J. H. Lee[4], H. Hyun[4], M. Kim[4], T.-Y. Koo[4], C.-C. Kao[2], T. Sekine[6,9], Yongjae Lee[1,6]*

Article

Mapping the emergence of molecular vibrations mediating bond formation

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Received: 18 October 2019
Accepted: 16 April 2020
Published online: 24 June 2020
Check for updates

Jong Goo Kim[1,2,3], Shunsuke Nozawa[4,5], Hanui Kim[1,2,3], Eun Hyuk Choi[1,2,3], Tokushi Sato[6,7], Tae Wu Kim[1,2,3], Kyung Hwan Kim[8], Hosung Ki[1,2,3], Jungmin Kim[1,2,3], Minseo Choi[1,2,3], Yunbeom Lee[1,2,3], Jun Heo[1,2,3], Key Young Oang[9], Kouhei Ichiyanagi[4], Ryo Fukaya[4], Jae Hyuk Lee[10], Jaeku Park[10], Intae Eom[10], Sae Hwan Chun[10], Sunam Kim[10], Minseok Kim[10], Tetsuo Katayama[11,12], Tadashi Togashi[11,12], Sigeki Owada[11,12], Makina Yabashi[11,12], Sang Jin Lee[1,2,3], Seonggon Lee[1,2,3], Chi Woo Ahn[1,2,3], Doo-Sik Ahn[1,2,3], Jiwon Moon[13], Seungjoo Choi[14], Joonghan Kim[13], Taiha Joo[8], Jeongho Kim[14], Shin-ichi Adachi[4,5] & Hyotcherl Ihee[1,2,3]✉

Won Namkung

ACS NANO
www.acsnano.org

High-Throughput 3D Ensemble Characterization of Individual Core–Shell Nanoparticles with X-ray Free Electron Laser Single-Particle Imaging

Do Hyung Cho,▽ Zhou Shen,▽ Yungok Ihm, Dae Han Wi, Chulho Jung, Daewoong Nam, Sangsoo Kim, Sang-Youn Park, Kyung Sook Kim, Daeho Sung, Heemin Lee, Jae-Yong Shin, Junha Hwang, Sung Yun Lee, Su Yong Lee, Sang Woo Han, Do Young Noh, N. Duane Loh,* and Changyong Song*

PHYSICAL REVIEW X 11, 031031 (2021)

Structural Evidence for Ultrafast Polarization Rotation in Ferroelectri Superlattice Nanodomains

Hyeon Jun Lee,[1] Youngjun Ahn,[1] Samuel D. Marks,[1] Eric C. Landahl,[2] Shihao Zhuang,[1] M
Matthew Dawber,[3] Jun Young Lee,[4] Tae Yeon Kim,[4] Sanjith Unithrattil,[4] Sae Hwan Chun,[5] Sun
Sang-Yeon Park,[5] Kyung Sook Kim,[5] Sooheyong Lee,[6,7] Ji Young Jo,[4] Jiamian Hu,[1] and

JACS JOURNAL OF THE AMERICAN CHEMICAL SOCIETY
pubs.acs.org/JACS Article

Optical Kerr Effect of Liquid Acetonitrile Probed by Femtosecond Time-Resolved X-ray Liquidography

Hosung Ki,▽ Seungjoo Choi,▽ Jungmin Kim, Eun Hyuk Choi, Seonggon Lee, Yunbeom Lee, Kihwan Yoon, Chi Woo Ahn, Doo-Sik Ahn, Jae Hyuk Lee, Jaeku Park, Intae Eom, Minseok Kim, Sae Hwan Chun, Joonghan Kim, Hyotcherl Ihee,* and Jeongho Kim*

nature COMMUNICATIONS
ARTICLE
https://doi.org/10.1038/s41467-021-25070-z OPEN
Check for updates

Filming ultrafast roaming-mediated isomerization of bismuth triiodide in solution

Eun Hyuk Choi[1,2], Jong Goo Kim[1,2], Jungmin Kim[1,2], Hosung Ki[1,2], Yunbeom Lee[1,2], Seonggon Lee[1,2], Kihwan Yoon[3], Joonghan Kim[3], Jeongho Kim[4] & Hyotcherl Ihee[1,2]✉

NANO LETTERS
pubs.acs.org/NanoLett Letter

Ultrafast Carrier–Lattice Interactions and Interlayer Modulations of Bi_2Se_3 by X-ray Free-Electron Laser Diffraction

Sungwon Kim, Youngsam Kim, Jaeseung Kim, Sungwook Choi, Kyuseok Yun, Dongjin Kim, Soo Yeon Lim, Sunam Kim, Sae Hwan Chun, Jaeku Park, Intae Eom, Kyung Sook Kim, Tae-Yeong Koo, Yunbo Ou, Ferhat Katmis, Haidan Wen, Anthony DiChiara, Donald A. Walko, Eric C. Landahl, Hyeonsik Cheong, Eunji Sim, Jagadeesh Moodera, and Hyunjung Kim*

PHYSICAL REVIEW LETTERS 127, 175003 (2021)

Investigation of Nonequilibrium Electronic Dynamics of Warm Dense Copper with Femtosecond X-Ray Absorption Spectroscopy

Jong-Won Lee,[1,2,†,‡] Minju Kim,[1,2,†] Gyeongbo Kang,[1,2] Sam M. Vinko,[3,4] Leejin Bae,[5] Min Sang Cho,[1,2] Hyun-Kyung Chung,[6] Minseok Kim,[7] Soonnam Kwon,[7] Gyusang Lee,[1,2] Chang Hee Nam,[1,2] Sang Han Park,[7] Jang Hyeob Sohn,[2] Seong Hyeok Yang,[2] Ulf Zastrau,[8] and Byoung Ick Cho[1,2,*]

THE JOURNAL OF PHYSICAL CHEMISTRY LETTERS
A JOURNAL OF THE AMERICAN CHEMICAL SOCIETY
pubs.acs.org/JPCL Letter

Ligand-Field Effects in a Ruthenium(II) Polypyridyl Complex Probed by Femtosecond X-ray Absorption Spectroscopy

Yujin Kim,⊥ Rory Ma,⊥ Junho Lee,⊥ Jessica Harich, Daewoong Nam, Sangsoo Kim, Minseok Kim, Miguel Ochmann, Intae Eom, Nils Huse,* Jae Hyuk Lee,* and Tae Kyu Kim*

PHYSICAL REVIEW X 12, 011013 (2022)

Ultrafast Renormalization of the On-Site Coulomb Repulsion in a Cuprate Superconductor

Denitsa R. Baykusheva,[1,*] Hoyoung Jang,[2] Ali A. Husain,[3,4,5] Sangjun Lee,[3,4] Sophia F. R. TenHuisen,[1,6] Preston Zhou,[1] Sunwook Park,[7,8] Hoon Kim,[7,8] Jin-Kwang Kim,[7,8] Hyeong-Do Kim,[2] Minseok Kim,[2] Sang-Youn Park,[2] Peter Abbamonte,[3,4] B. J. Kim,[7,8] G. D. Gu,[9] Yao Wang,[10,†] and Matteo Mitrano[1,‡]

PLS-II

Energy upgrade: 2.5 => 3.0 GeV

Top-up operation

Normal conducting RF => Super conducting RF

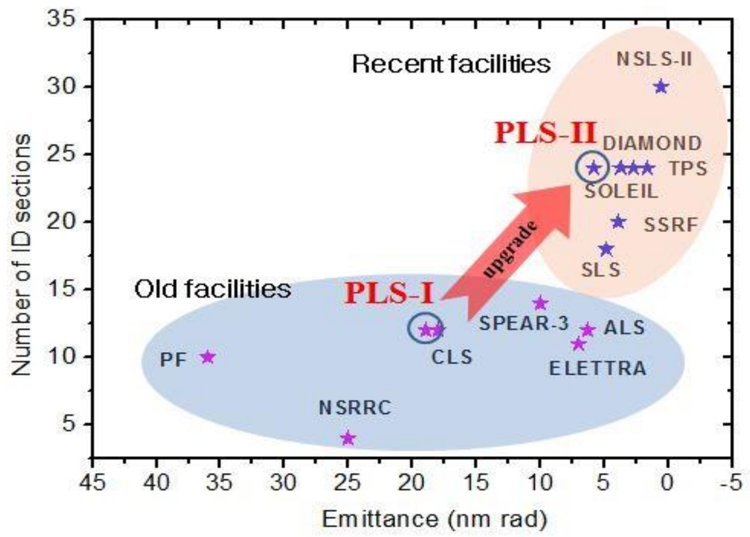
One year for user beam-time interruption

PLS-II Upgrade Storage Ring

○ **Main goals**

- **Beam energy : 2.5 → 3.0 GeV**
- **Current : 200 → 400 mA**
- **Storage Ring Emittance : 18.9 → 5.8 nm**
- **Top-up Operation mode**
- **No. of Insertion Device : 10 → 20**
- **Superconducting RF cavities**

The 3rd generation synchrotron facilities



PLS

PLS

Dismantling

DEC. ‘10

Re-installation

JAN. ‘11

PLS-II

PLS-II

Won Namkung

POHANG ACCELERATOR LABORATORY

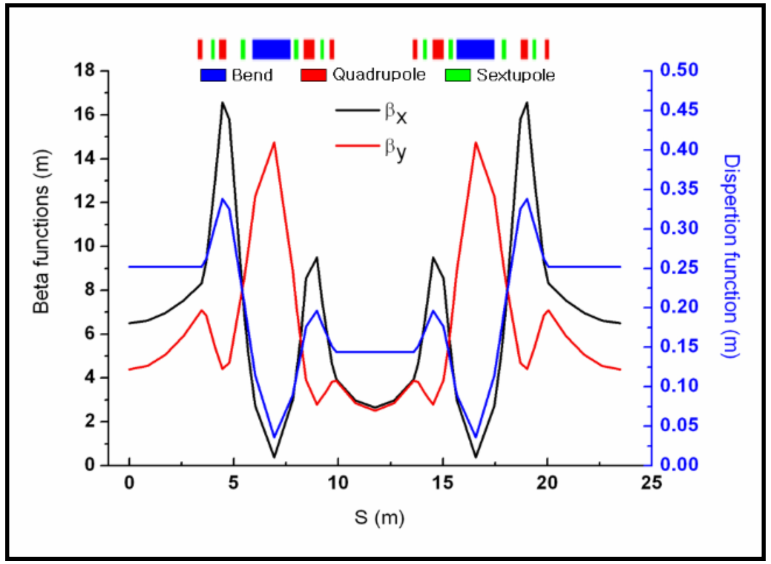
PLS-II Linac

- Thermionic Electron Gun
- 17 Pulse Modulators (200MW, 7.5μs)
- 17 Klystrons (80 MW, 4μs)
- 16 Energy Doublers (gain=1.5)
- 46 Accelerating Sections

Injector LINAC

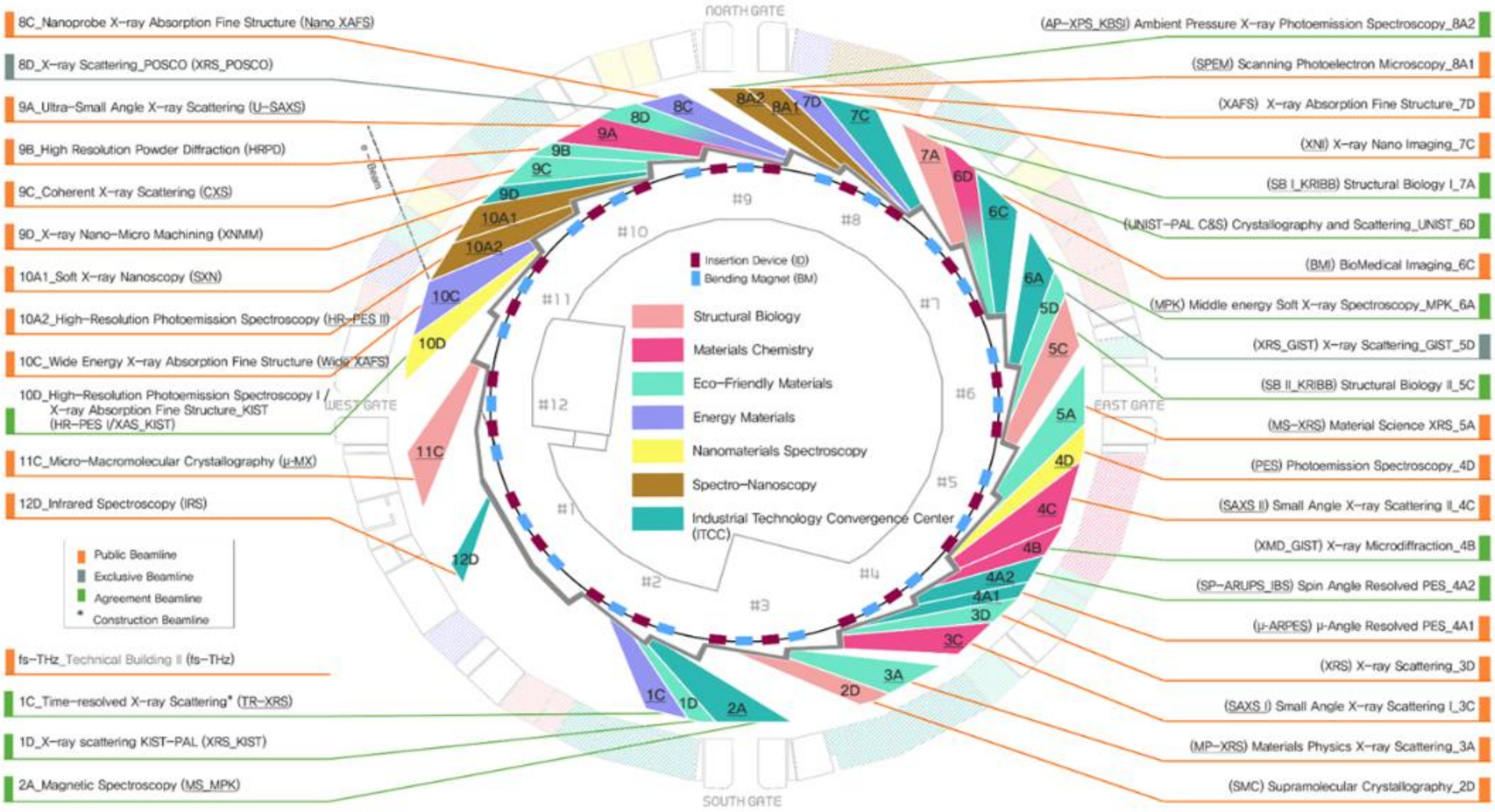
- Length = 170m
- 3.0 GeV, full energy injection
- 2,856 MHz (S-band)
- 10 Hz, 1.5 ns, 1Å pulsed beam
- Norm. emmittance: 150 μmrad

PLS-II Parameters

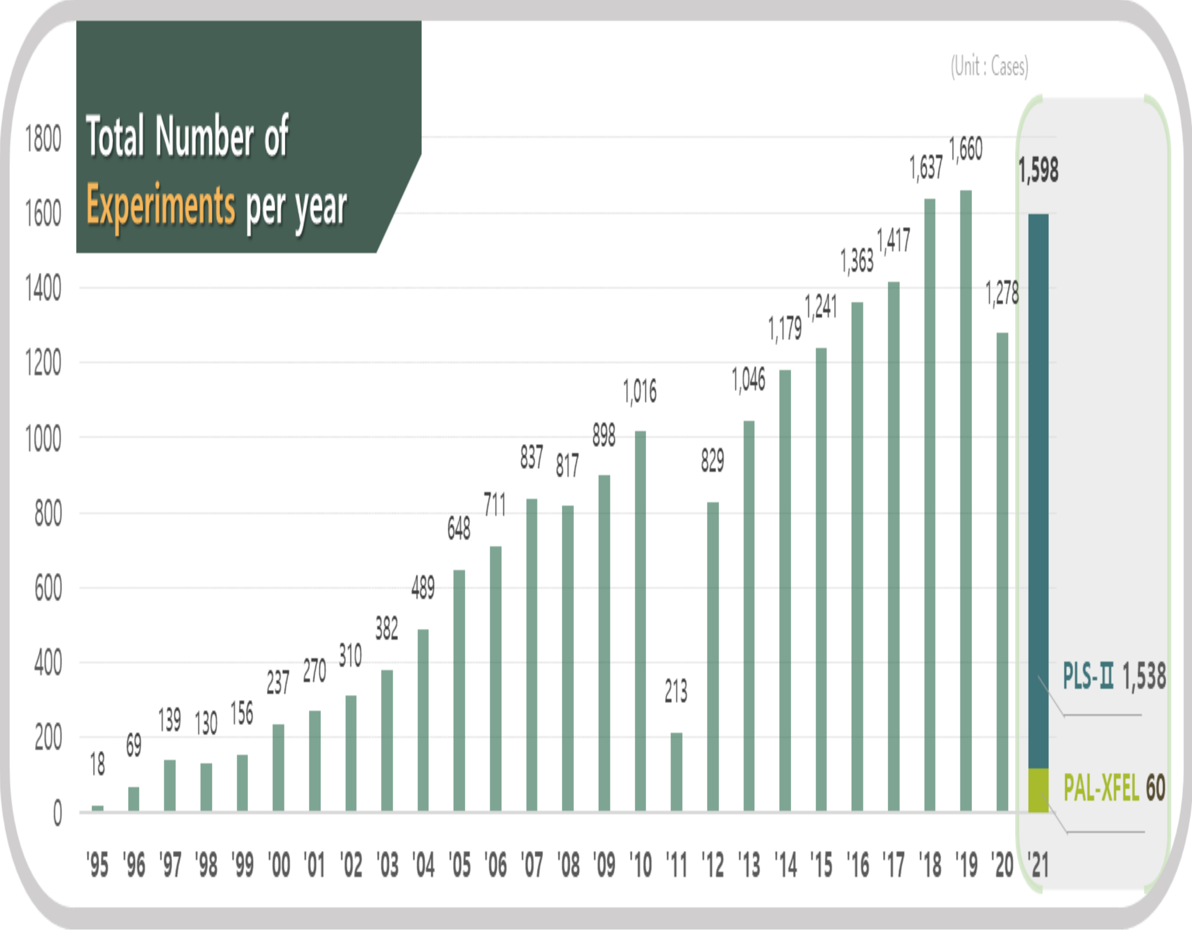


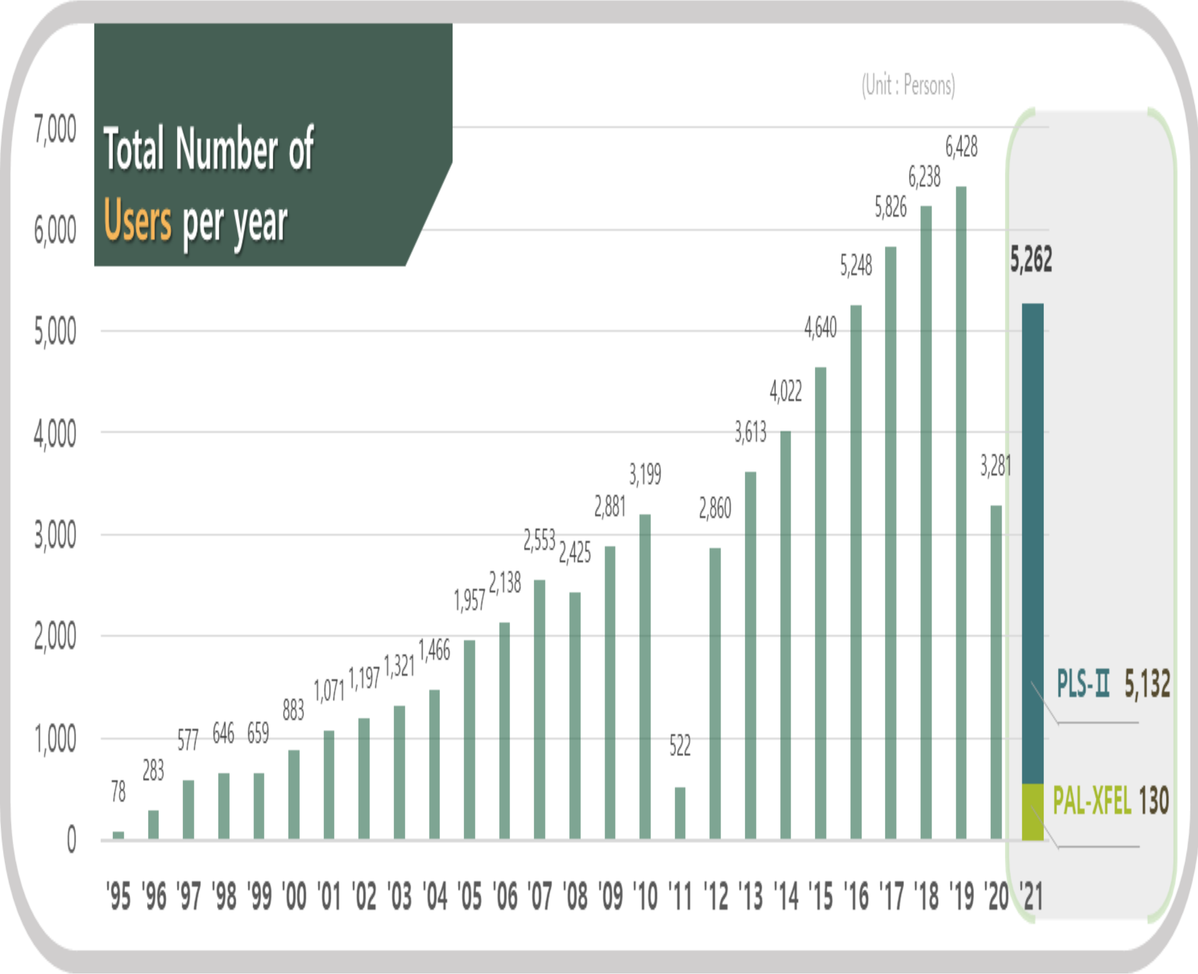
- **Beam Energy** **3.0 GeV**
- **Beam Current** **400 mA**
- **Lattice** **DBA**
- **Superperiods** **12**
- **Emittance** **5.8 nm·rad**
- **Tune** **15.37 / 9.15**
- **SRF Frequency** **499.97 MHz**
- **Circumference** **280 m**

36 Beam-lines at PLS-II



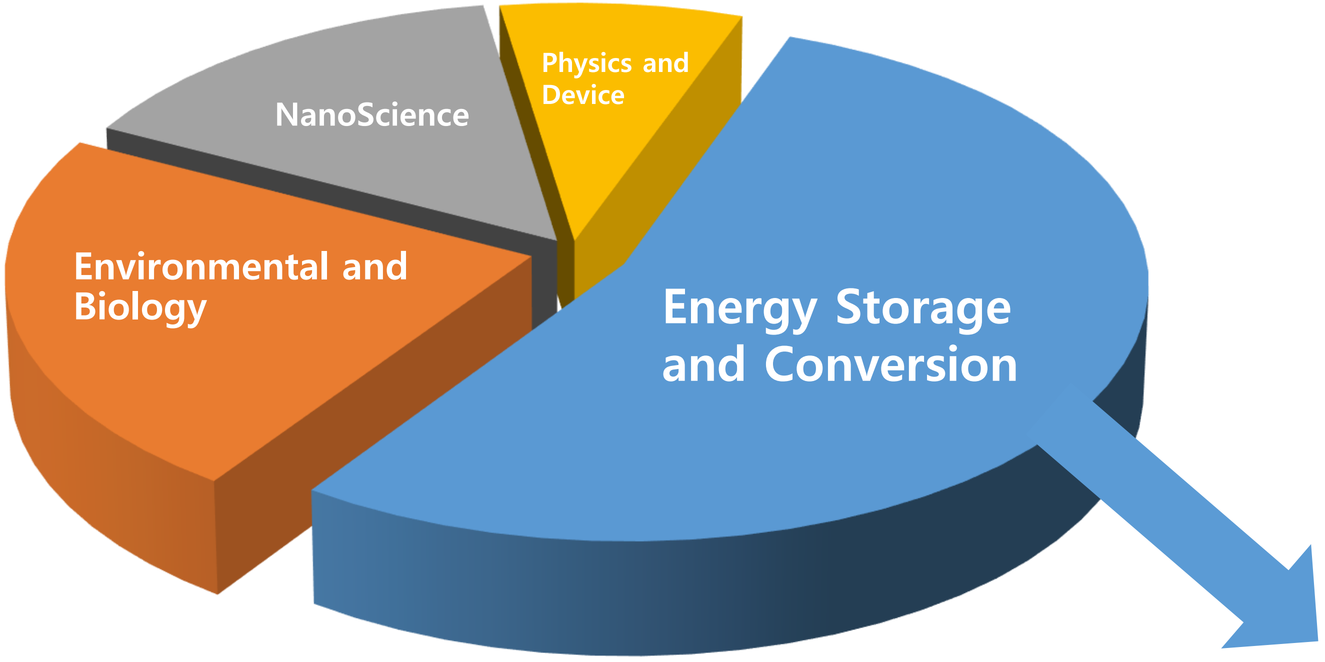
Number of Experiments and Users per Year





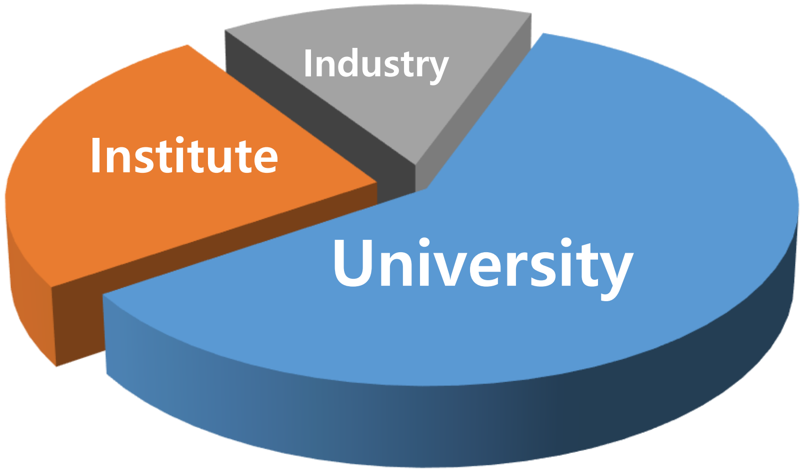
User Sciences in PLS-II

Research Fields

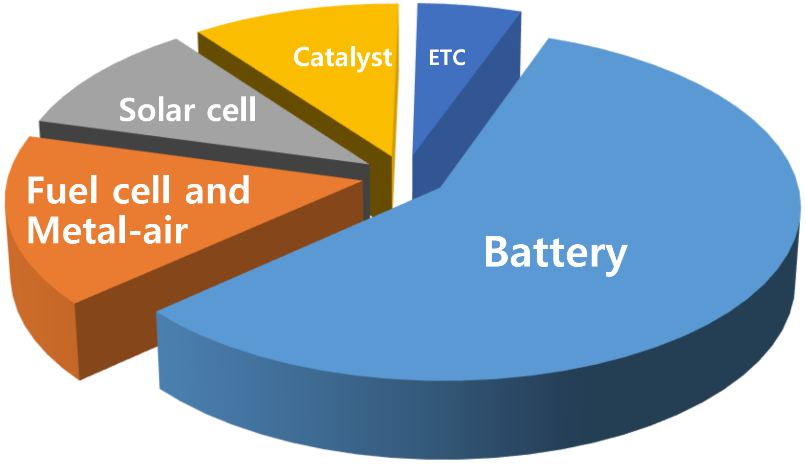


- **Li-ion battery***, Fuel cell, Solar cell and Metal-Air battery, Photocatalyst
- **Drug design, Environmental materials**, Biomass, Micro-organics
- **Nanochemistry** & Engineering
- **Memory***, Semiconductor, Display

User Affiliations



Energy Storage and Conversion



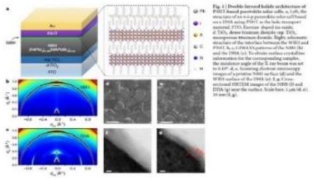
2020-2021 User Scientific Representative Achievements-I

Focused on *Energy conversion and storage Materials and Nanochemistry*

Solar cell

nature LETTER

Efficient, stable and scalable perovskite solar cells using poly(3-hexylthiophene)



Electrocatalyst

ARTICLES — nature materials

Atomic-level tuning of Co-N-C catalyst for high-performance electrochemical H_2O_2 production

Euiyeon Jung, Heejong Shin, Byoung-Hoon Lee, Vladimir Efremov, Suhyeong Lee, Hyeon Seok Lee, Jiheon Kim, Wytse Hooch Antink, Subin Park, Kug-Seung Lee, Sung-Pyo Cho, Jong Suk Yoo, Yung-Eun Sung and Taeghwan Hyeon

Li-ion Battery

NATURE MATERIALS | VOL 19 | APRIL 2020 | 419–427 | www.nature.com/naturematerials

ARTICLES — nature materials

Voltage decay and redox asymmetry mitigation by reversible cation migration in lithium-rich layered oxide electrodes

Donggun Eum, Byunghoon Kim, Sung Joo Kim, Hyeokjun Park, Jinpeng Wu, Sung-Pyo Cho, Gabin Yoon, Myeong Hwan Lee, Sung-Kyun Jung, Wanli Yang, Won Mo Seong, Kyojin Ku, Orapa Tamwattana, Sung Kwan Park, Insang Hwang and Kisuk Kang

Nanochemistry & Catalyst

Science

Song *et al.*, *Science* **367**, 777–781 (2020) 14 February 2020

CATALYSIS

Dry reforming of methane by stable Ni–Mo nanocatalysts on single-crystalline MgO

Electrocatalyst

nature catalysis

Article | Published: 29 June 2020

Selective electrocatalysis imparted by metal–insulator transition for durability enhancement of automotive fuel cells

Sang-Mun Jung, Su-Won Yun, Jun-Hyuk Kim, Sang-Hoon You, Jinheon Park, Seonggyu Lee, Seo Hyoung Chang, Seung Chul Chae, Sang Hoon Joo, Yousung Jung, Jinwoo Lee, Junwoo Son, Joshua Snyder, Vojislav Stamenkovic, Nenad M. Markovic & Yong Tae Kim

Nature Catalysis 3, 639–648(2020) | Cite this article

Electrocatalyst

nature catalysis

Article | Published: 17 February 2020

Highly durable metal ensemble catalysts with full dispersion for automotive applications beyond single-atom catalysts

Hojin Jeong, Ohmin Kwon, Beom Sik Kim, Junemin Bae, Sangyong Shin, Hee Eun Kim, Jihan Kim & Hyunjoo Lee

Nature Catalysis 3, 368–375(2020) | Cite this article

Solar cell

nature energy — ARTICLES

Stabilization of formamidinium lead triiodide α-phase with isopropylammonium chloride for perovskite solar cells

Byung-wook Park, Hyoung Woo Kwon, Yonghui Lee, Do Yoon Lee, Min Gyu Kim, Geonhwa Kim, Ki-jeong Kim, Young Ki Kim, Jino Im, Tae Joo Shin and Sang Il Seok

Nanochemistry

nature

Article

Design and synthesis of multigrain nanocrystals via geometric misfit strain

Electrocatalyst

ARTICLES — nature catalysis

Redirecting dynamic surface restructuring of a layered transition metal oxide catalyst for superior water oxidation

Jian Wang, Se-Jun Kim, Jiapeng Liu, Yang Gao, Subin Choi, Jeongwoo Han, Hyeyoung Shin, Sugeun Jo, Juwon Kim, Francesco Ciucci, Hwiho Kim, Qingtian Li, Wanli Yang, Xia Long, Shihe Yang, Sung-Pyo Cho, Keun Hwa Chae, Min Gyu Kim, Hyungjun Kim and Jongwoo Lim

Memory device

ARTICLES — nature materials

A bioinspired and hierarchically structured shape-memory material

Luca Cera, Grant M. Gonzalez, Qihan Liu, Suji Choi, Christophe O. Chantre, Juncheol Lee, Rudy Gabardi, Myung Chul Choi, Kwanwoo Shin and Kevin Kit Parker

Catalyst

nature

Article

Rare-earth–platinum alloy nanoparticles in mesoporous zeolite for catalysis

Semiconductor

nature

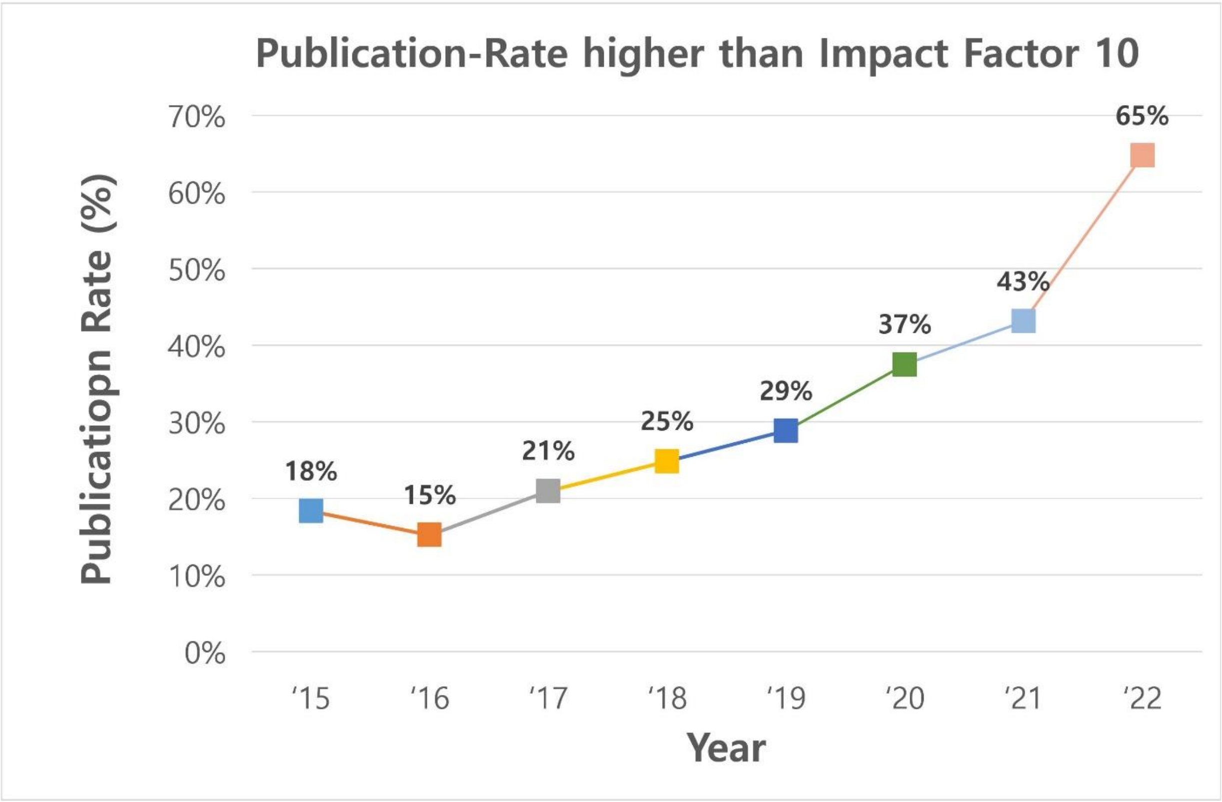
Article

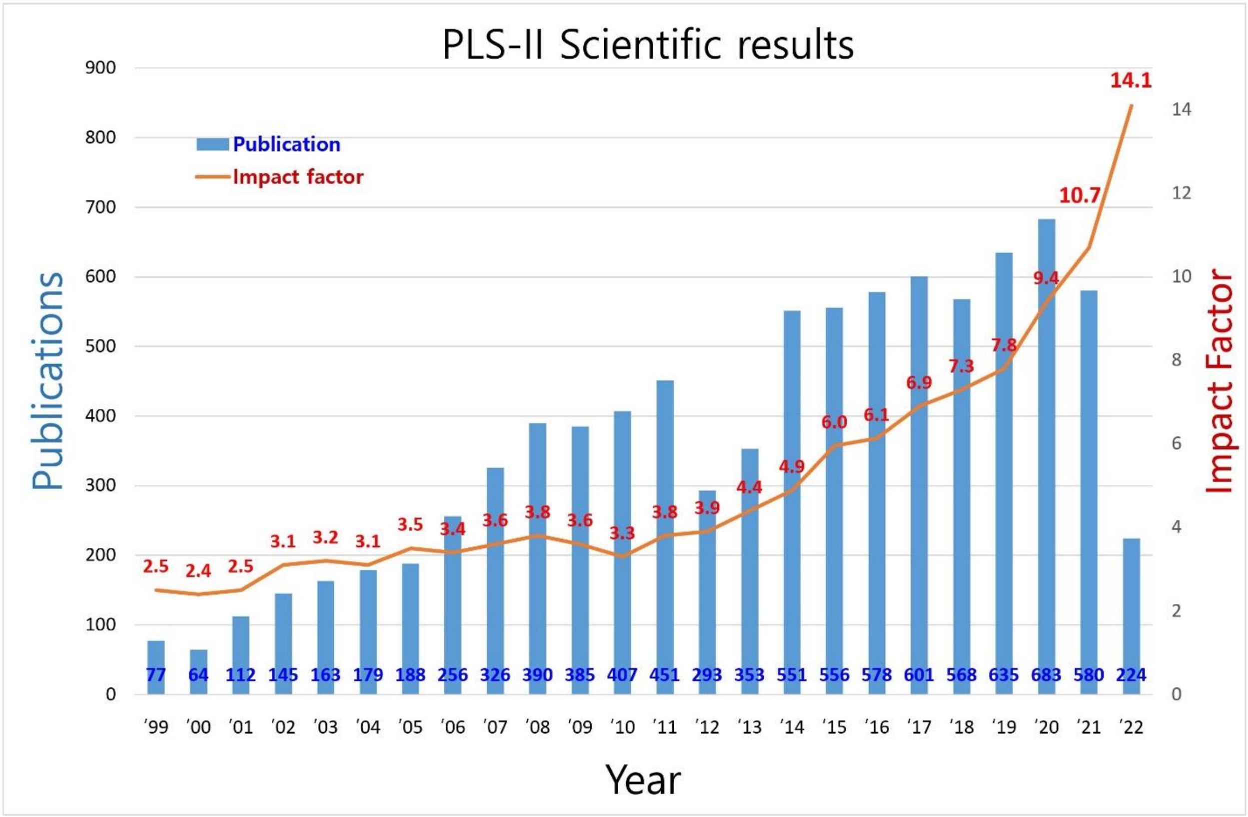
Ultralow-dielectric-constant amorphous boron nitride

PAL POHANG ACCELERATOR LABORATORY

2022 User Scientific General Achievements-II

An increasing trend **of Impact factor**
Constant SCI Publications

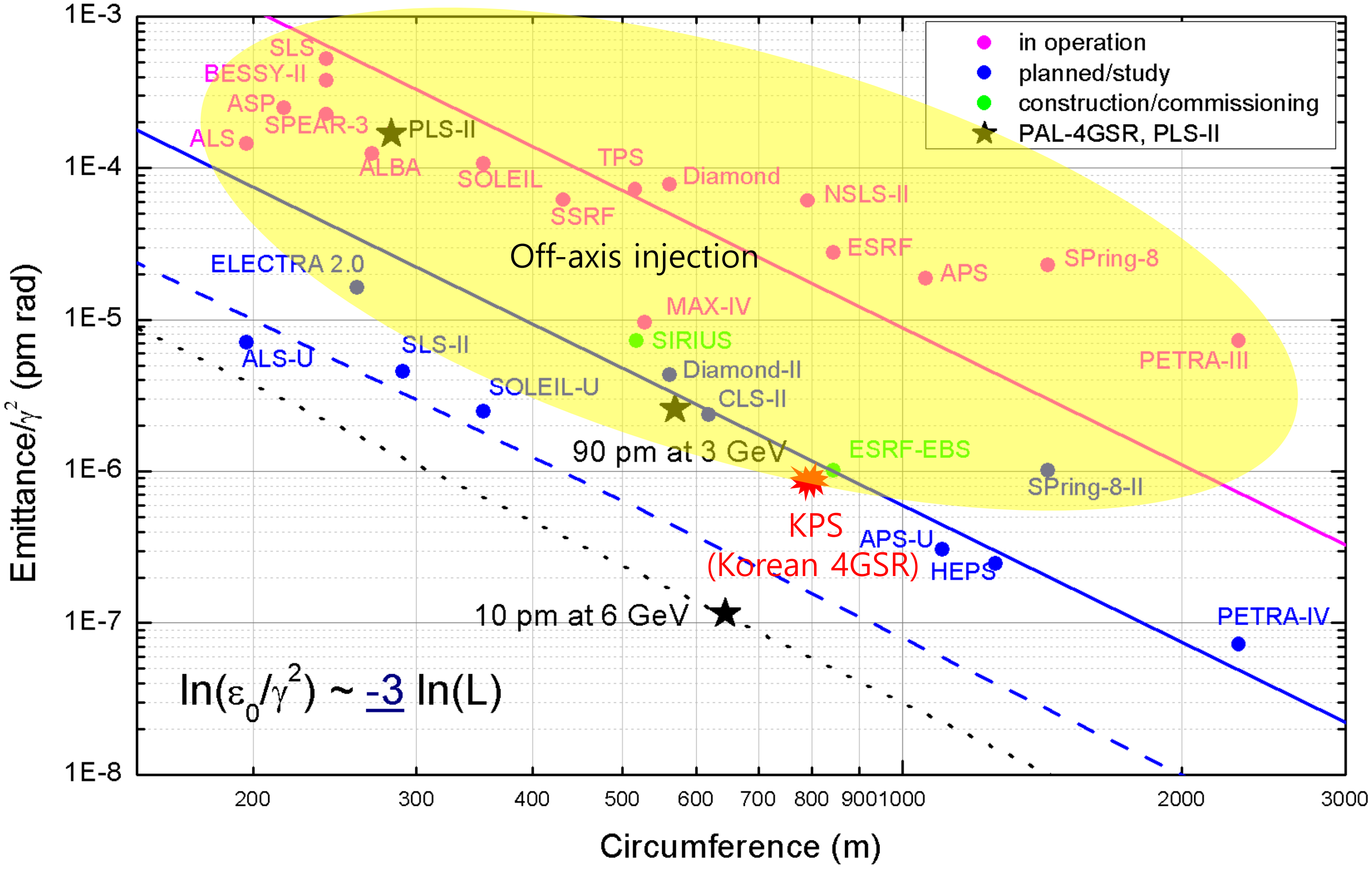




KPS (Korea Photon Source)

Users are increasing
Available Beam-lines are limited at 36
High-performance beams are in demand
There is no space left at PAL

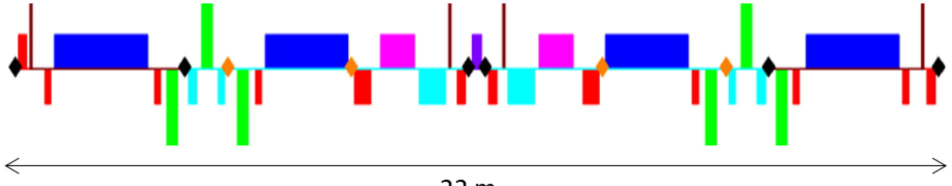
3rd and 4th Generation Light Sources

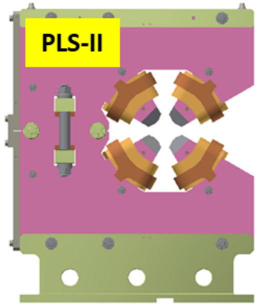


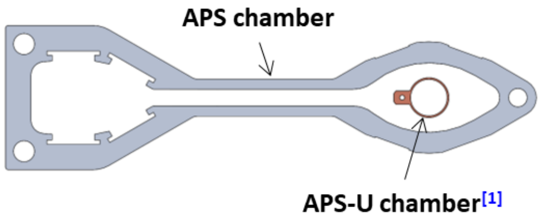
3GSR vs. 4GSR (with challenging technology)

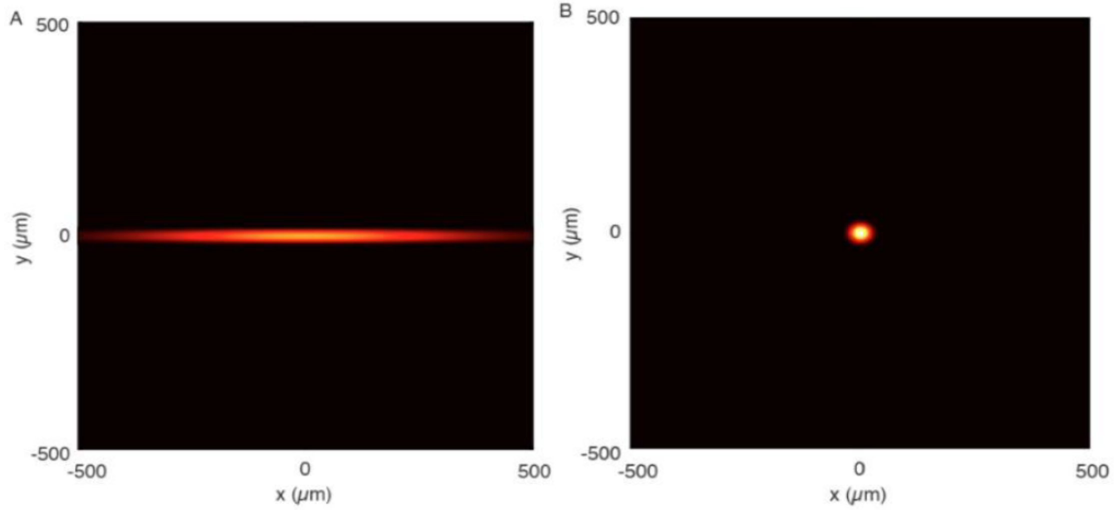
- The 3rd Generation Storage Ring Lattice:

- The 4th Generation Storage Ring Lattice:









Korea Photon Source (KPS) ***Project***

- Preliminary study by PAL: 2017 ~ 2019

- CDR project: 2020

- Project start: 2021. 7 ~ 2027. 12

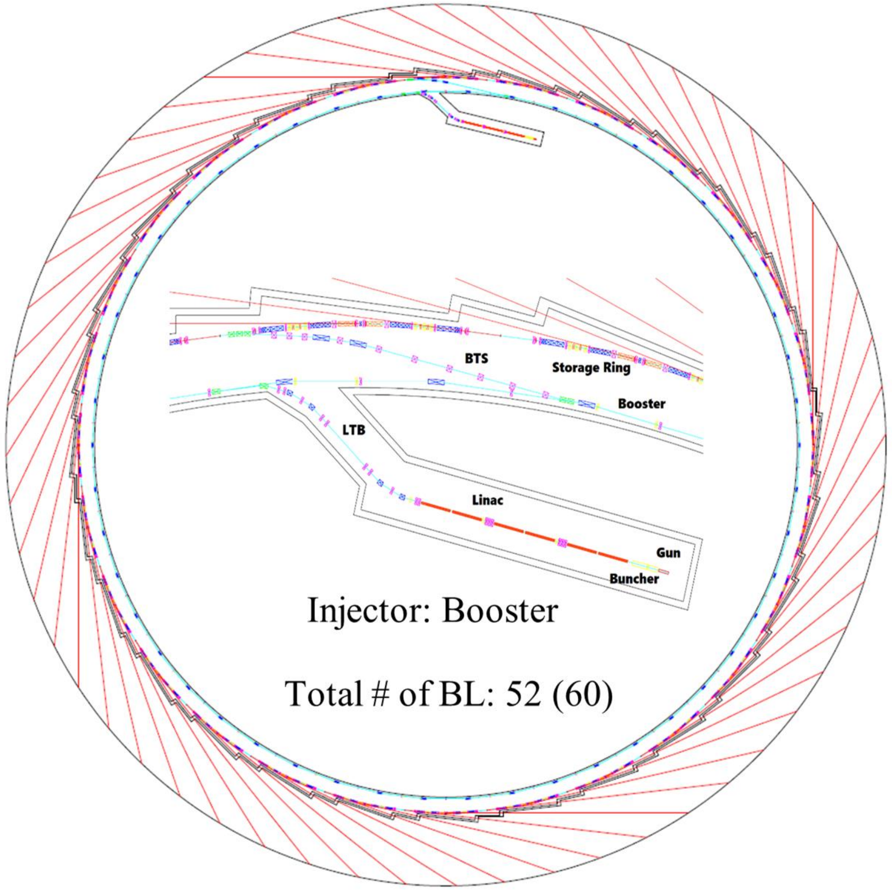
- Building by KBSI / Machine by PAL

Parameter	Units	PLS-II	Korean 4GSR
Electron energy	GeV	3	4
Horiz. Emittance	pm	5,800	58 (RB: 39)
Vert. Emittance	pm	~ 58	~ 5.8 (RB: 39)
Bunch length (rms)	ps	20	13 (50 with HC)
Circumference	m	280	800
Harmonic #		470	1332
RF frequency	MHz	500	500
Beam stability @ ID (x/y)	μm	< 4 / 2	< 2.5 / 0.45
Injection mode		Top-up	Top-up

Major Parameters for KPS

4GSR Ring		Value	Unit
Design Parameters	Cell Number	28	-
	Circumference	**798.84**	**[m]**
	Electron Energy	**4**	**[GeV]**
	Natural Emittance	**58**	**[pm rad]**
Tune and Chromaticiy	Horizontal Tune	67.395	-
	Vertical Tune	24.275	-
	Natural Horizontal Chromaticity	-115.344	-
	Natural Vertical Chromaticity	-84.693	-
	Horizontal Chromaticity	3.5	(target)
	Vertical Chromaticity	3.5	(target)
Radiation related quantities	**Energy Loss per Turn**	**1009**	**[keV]**
	Energy Spread	0.1197	[%]
	Horizontal Damping Time	11.075	[ms]
	Vertical Damping Time	21.127	[ms]
	Longitudinal Damping Time	19.342	[ms]
Twiss functions at the ID	Horizontal beta function at the ID center	8.564	[m]
	Vertical beta function at the ID center	2.459	[m]
	Dispersion function at the ID center	1.3	[mm]

32



Won Namkung

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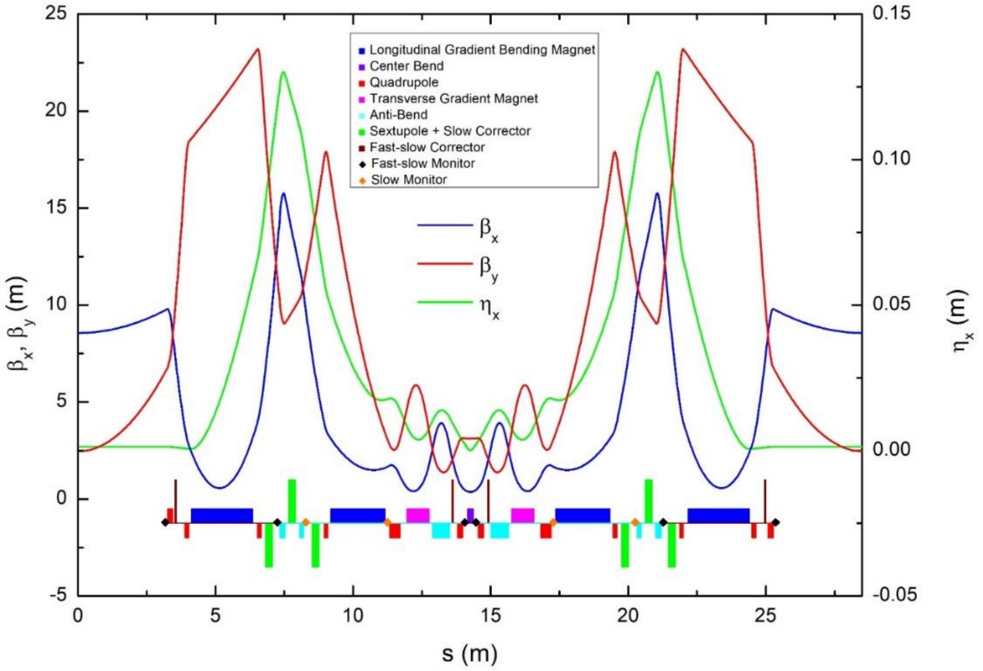
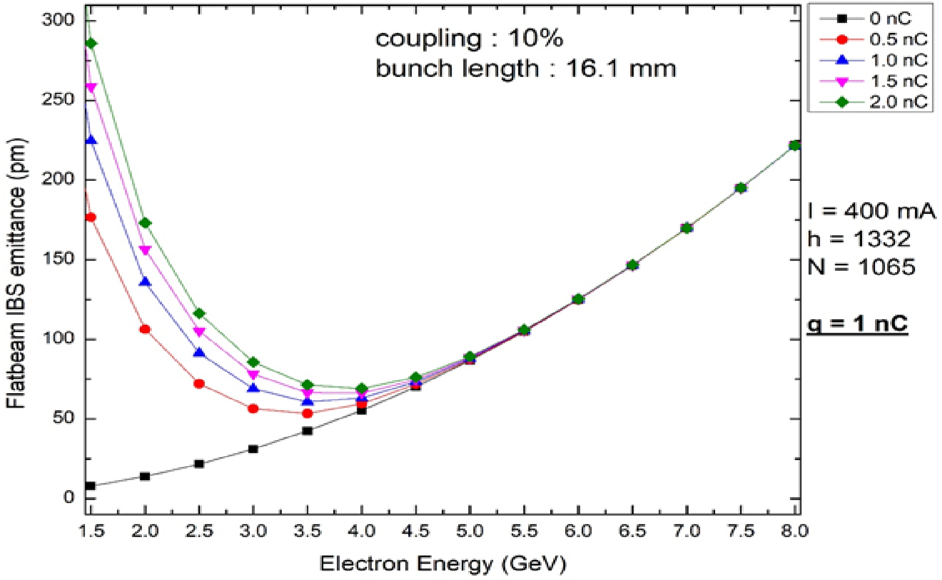
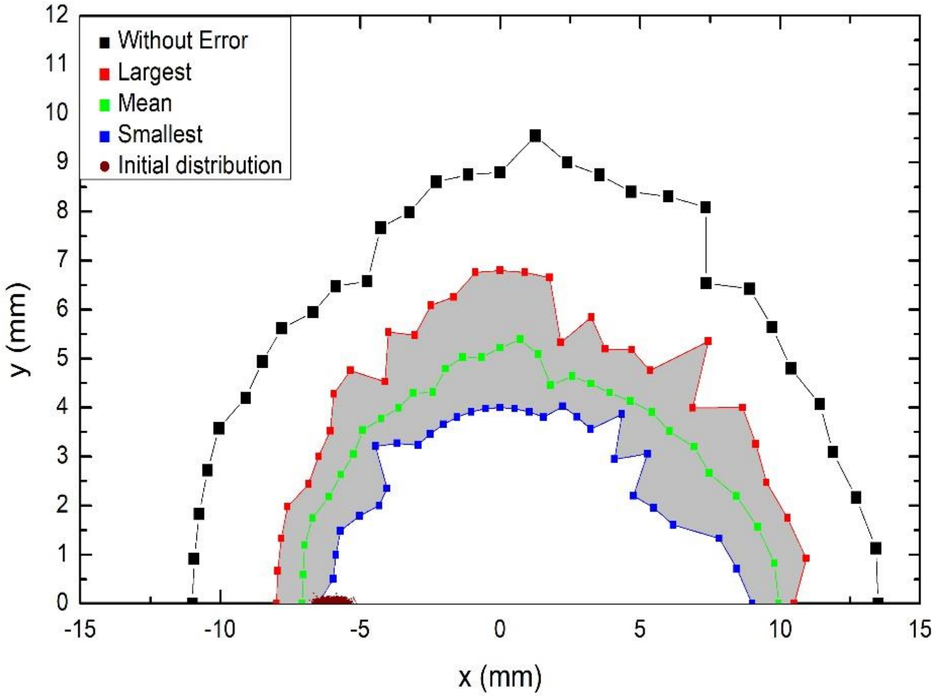
SR Lattice Structure (linear)

1. Natural evolution of ESRF-EBS and APS-U
2. ESRF-EBS type
   - Dispersion bump w/sextupoles.
   - Longitudinal gradient dipoles.
   - Phase advance of $\Delta\varphi_x \sim 3\pi$ and $\Delta\varphi_y \sim \pi$ between corresponding sextupole
3. APS-U type: Reverse bends in Q4, Q5, and Q8.
4. Massive use of combined function magnets
5. 6.5 m straight section and 2 T center-bend (E_c=21 keV)

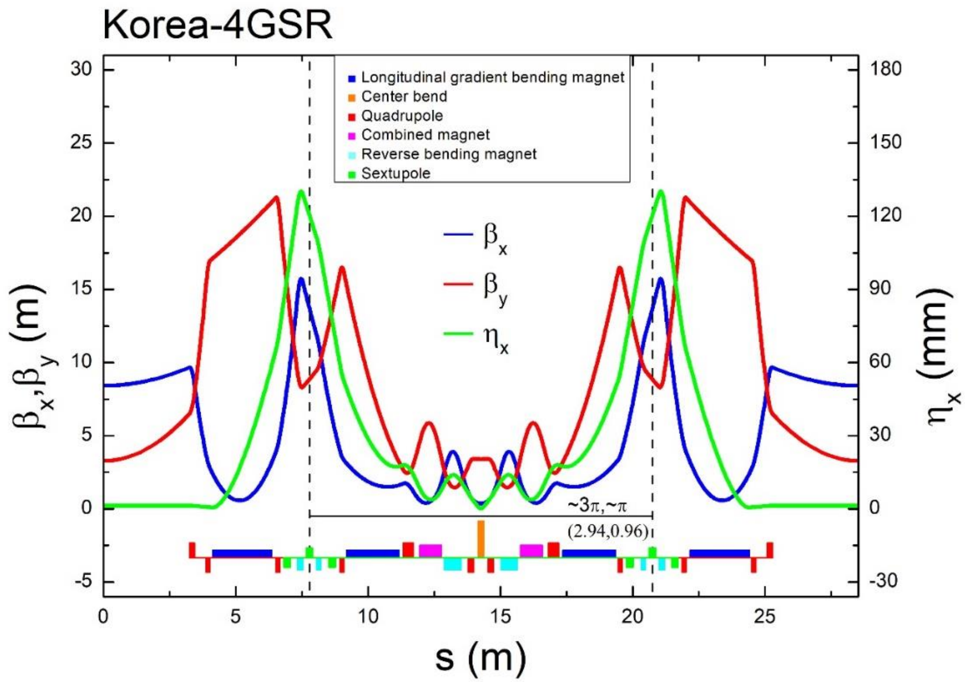


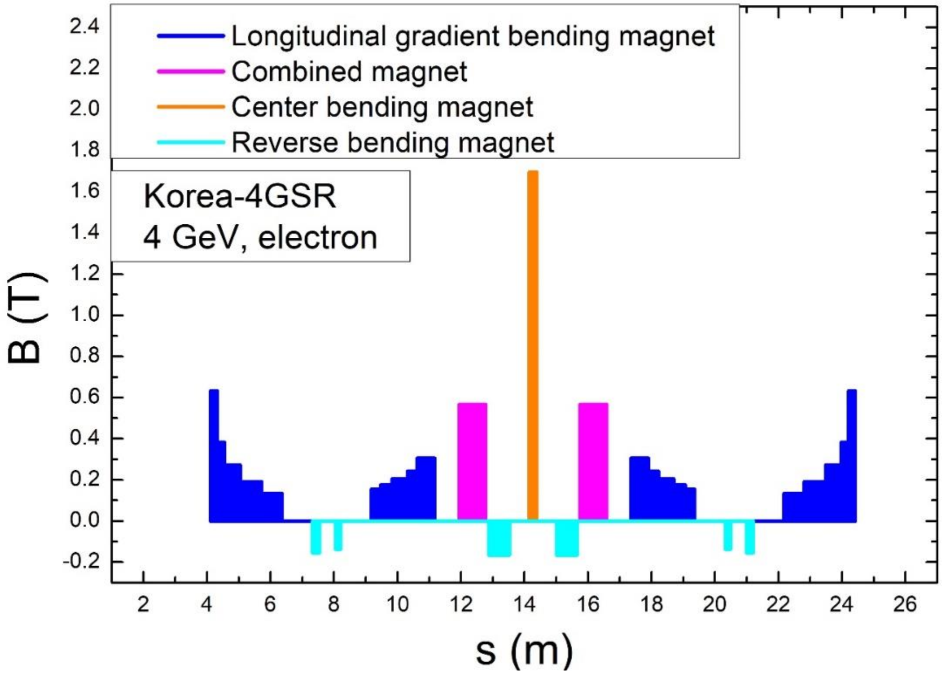
Minimum emittance @ 4 GeV



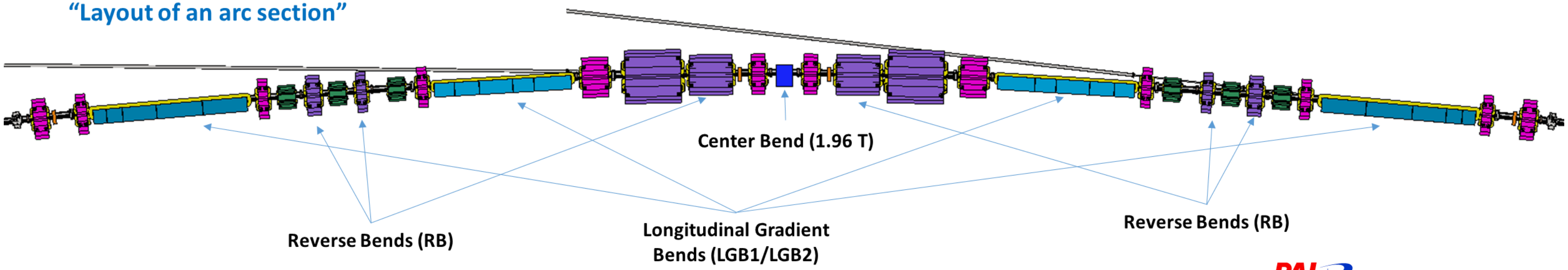


Hybrid 7-bend Achromat





"Layout of an arc section"



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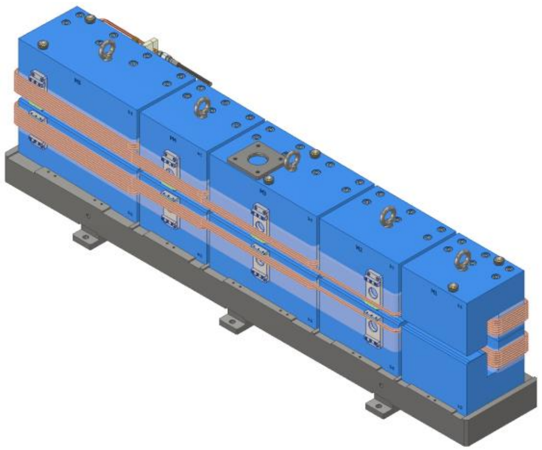
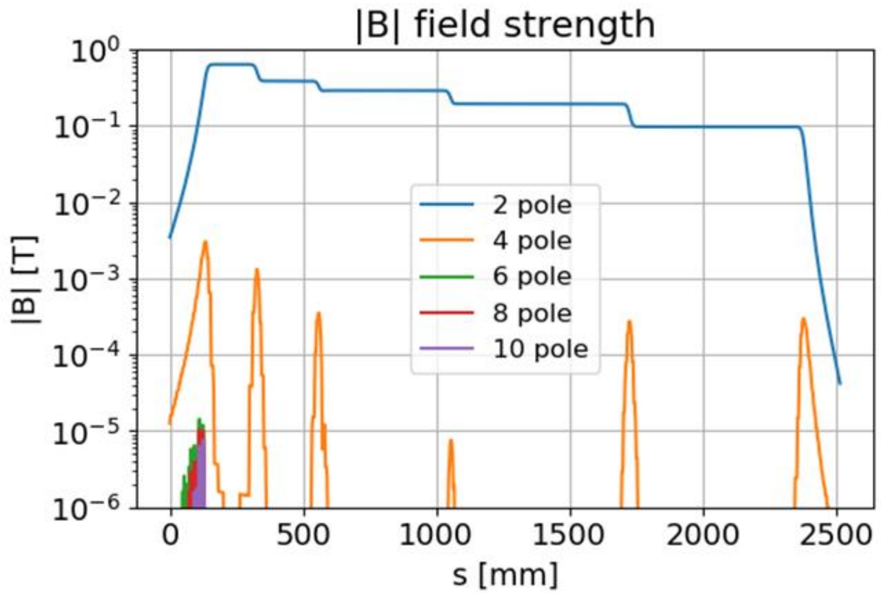
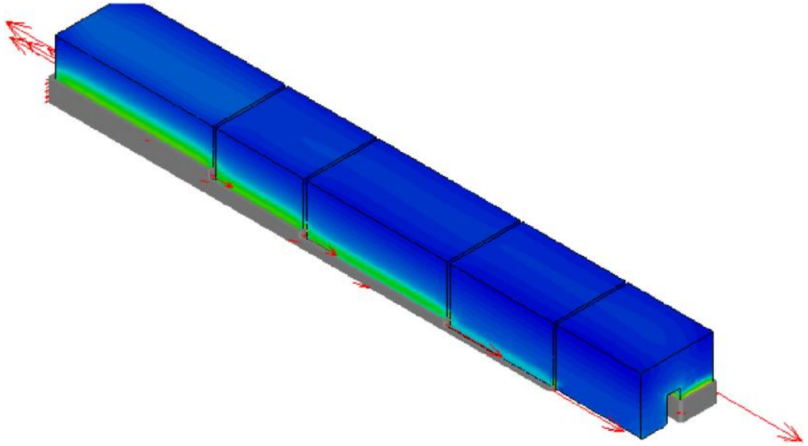
Longitudinal Gradient Bending Magnet (LGBM)



Dipole and higher order multipole along the orbit.





- EM version is selected for construction costs and total cost of operation during the lifetime.
- 3D field map with 1mm step size is calculated, and the multipole along the orbit is calculated.
- Except the quadrupole component which comes from the edge focusing, higher order was negligible.
- To match the design field, reluctance gap at the return yoke is implemented for each magnet section

Design Features

❖ **High photon beam performance from storage ring.**

- The best performance in the range of 10 ~ 40 keV.

- Capability to generate photon beam up to 100 keV.

❖ **Considering well demonstrated technologies for the design.**

- Off axis injection with conventional injection scheme

- General technologies for magnet and vacuum systems.

❖ **Synergy with PLS-II and PAL-XFEL.**

- Supporting full range of synchrotron radiation application.

Initial Beam-lines (10 units)

Beam-line	Beam Energy	Resolution	Source	Experimental Technique
① BioPharma-BioSAXS	5~20 keV	SAXS: < 1 Å $\Delta E/E < 10^{-4}$	IVU	① Bio-SAXS
② Material Structure Analysis	5~40 keV	$\Delta E/E < 10^{-4}$	Undulator	① XRD ② XAFS
③ Soft X-ray Nano-probe	0.1~5.0 keV	sub-micro beam $\Delta E/E > 1.5\times10^{-4}$@1keV	EPU	① XAS ② XPS
④ Nanoscale Angle-resolved Photoemission	0.1~2 keV	< 100 nm $\Delta E/E < 10^{-4}$	Undulator	① Nano-ARPES
⑤ Coherent X-ray Diffraction	3~30 keV	sub-micro beam	Undulator	① XRD ② CDI
⑥ Coherent Small-angle X-ray Scattering	4~40 keV	few nm ~ few µm $\Delta E/E < 2\times10^{-4}$	IVU	① SAXS/WAXS ② XPCS
⑦ Real-time X-ray Absorption Fine Structure	5~40 keV	Few µm	Undulator	① XAFS
⑧ Bio Nano crystallography	5~20 keV	< 1 Å	IVU	① MX
⑨ High Energy Microscopy	5 ~ 100 keV	resolution 0.1µm	Superbend	① Projection imaging
⑩ Nano-probe	5~25 keV	< 50nm 1~10 µm	IVU	① Ptychography/XRF ② XRS

Site Arrangement (Plan)

Summary

- **A few visionary people initiated light source facility in Korea in late 1980s.**
- **Successful constructions and user services at PAL have been recognized**
- **There are more accelerator projects being undertaken recently.**
- **The users' quality is continuously improved, and we expect more impact results.**
- **We need more technological development for effective domestic maintenance capability, for example, high-power klystrons, superconducting cavities, and cryogenic facilities.**

Acknowledgements

Thanks to

C. B. Kim: PAL-XFEL
I. T. Uom: PAL-XFEL
S. H. Shin: PLS-II
M. K. Kim: PLS-II
K. W. Kim: PAL
I. S. Ko: KPS

for their contribution

First Publication by First User

Science

Draft Manuscript: Confidential 18 August 2017

Title: Maxima in the Thermodynamic Response and Correlation Functions of Deeply Supercooled Water

Authors: Kyung Hwan Kim[1†], Alexander Späh[1†], Harshad Pathak[1], Fivos Perakis[1], Daniel Mariedahl[1], Katrin Amann-Winkel[1], Jonas A. Sellberg[2], Jae Hyuk Lee[3], Sangsoo Kim[3], Jaehyun Park[3], KiHyun Nam[3], Tetsuo Katayama[4], and Anders Nilsson[1,*]

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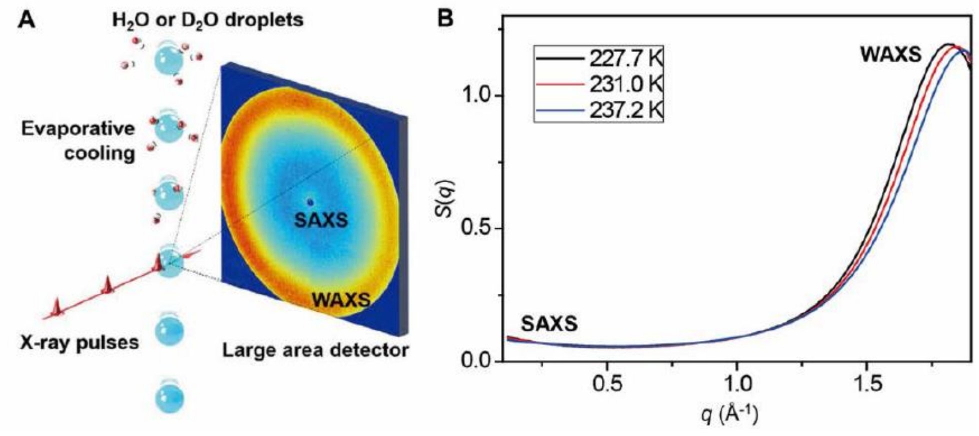
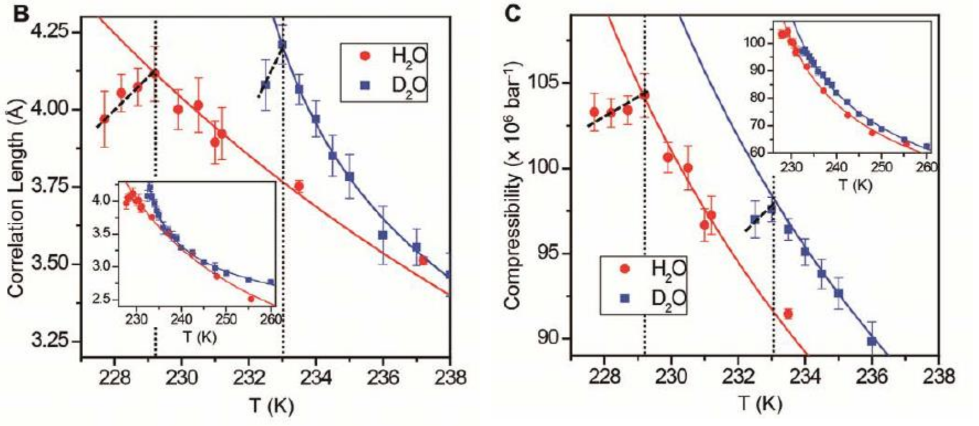
Abstract:

Femtosecond x-ray laser pulses were used to probe micron-sized water droplets cooled down to 227 K. From the x-ray scattering at the low momentum transfer region the isothermal compressibility and correlation length were extracted and the temperature dependence shows maxima at 229 K for H_2O and 233 K for D_2O. In addition, from the first diffraction peak it was observed that the liquid undergoes the most rapid growth of tetrahedral structures at similar temperatures. These observations point to the existence of a Widom line, defined as the locus of maximum correlation length emanating from a critical point at positive pressures deeply in the supercooled regime. The difference in maximum value of the isothermal compressibility between the two isotopes shows the importance of nuclear quantum effects.



Confirmation of the Existence of the Widom Line !



Science (Dec. 21, 2017)