Overview of Light Source Developments in Asia/Oceania

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SHINE(Shanghai High Repetition XFEL and Extreme Light)

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SHINE

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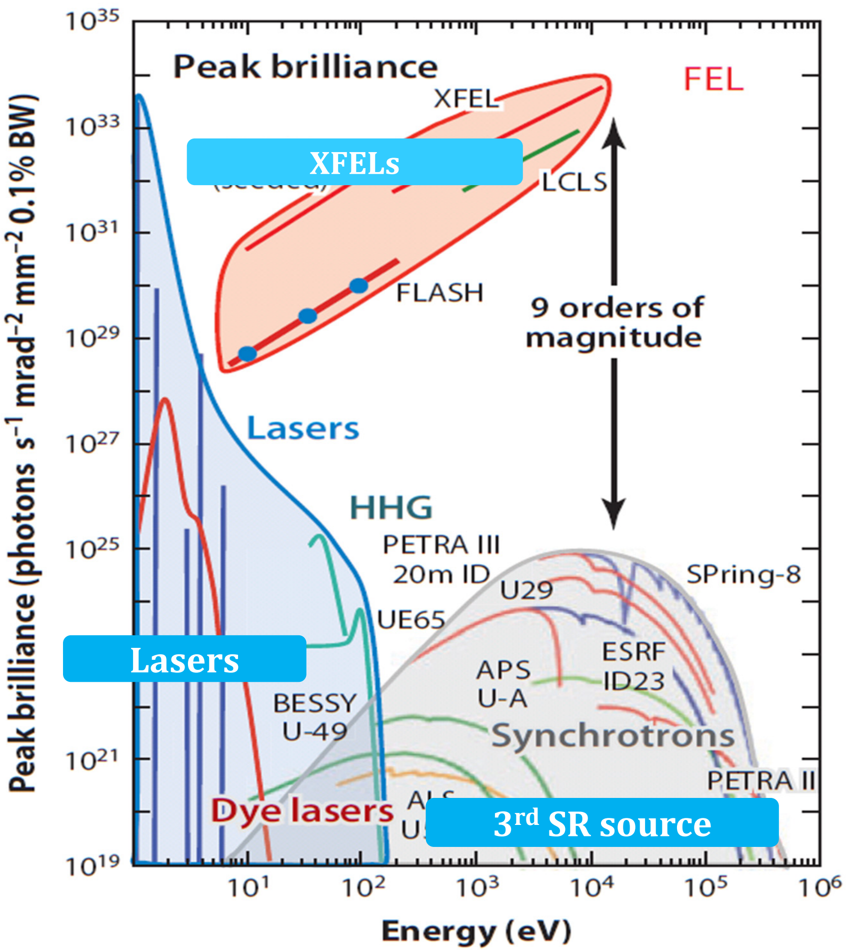
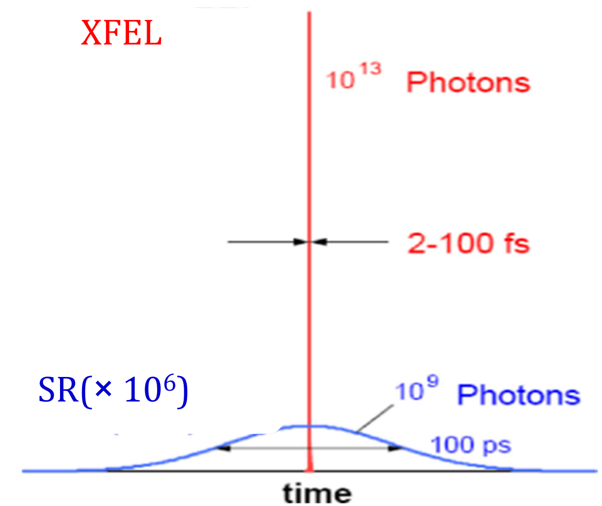
Synchrotron and FEL Light Sources: complementary



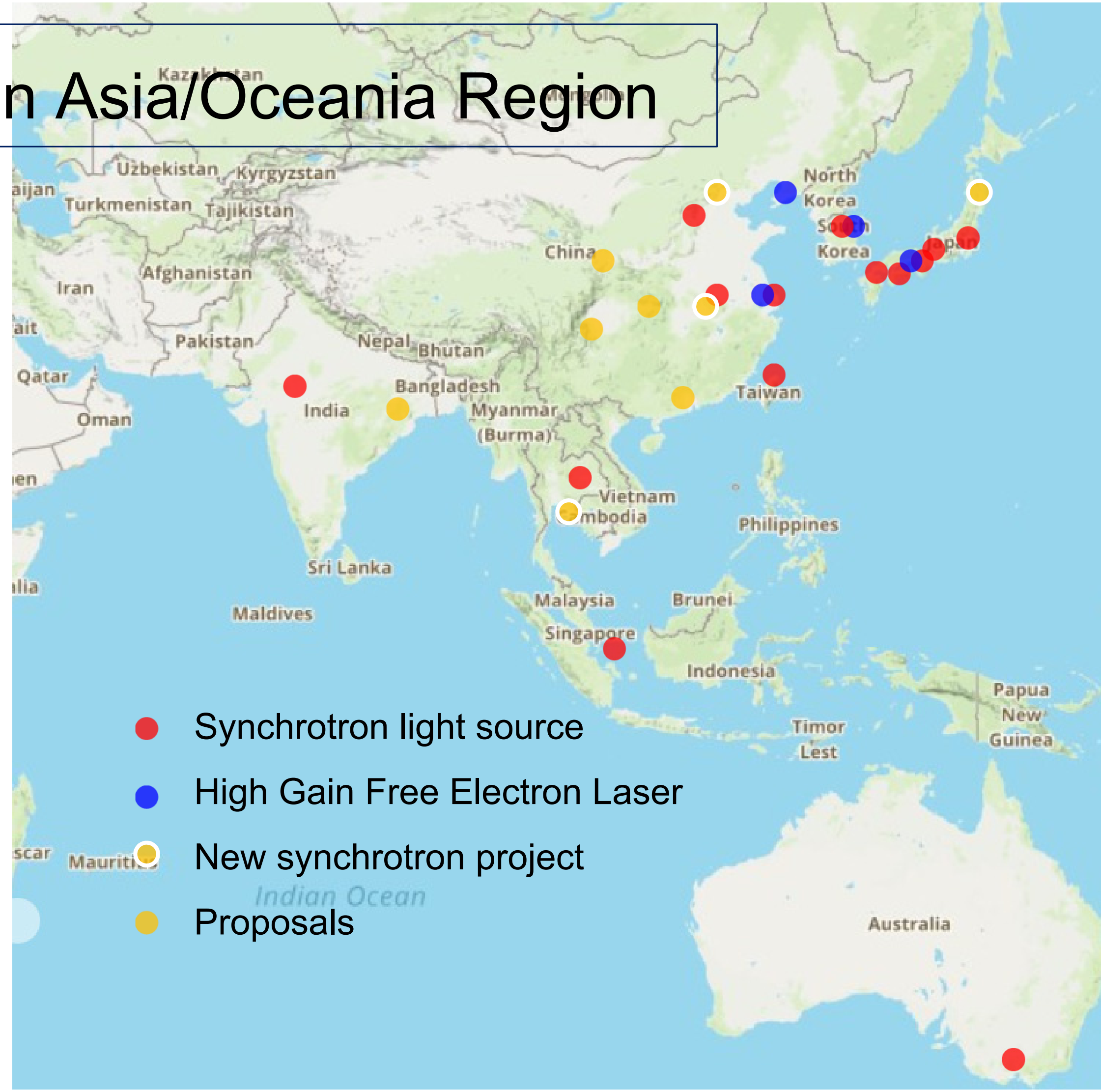
Synchrotron light source
- High brightness x-ray
- Large number of beamlines/stations
- Very reliable/stable operation



High gain free electron laser
- Fully coherent and ultra fast
- Ultra high brightness x-ray
- Increasing number of beamlines/stations

Light Sources in Asia/Oceania Region

- Australia: Australian Synchrotron(Clayton)
- China: BSRF(Beijing), SSRF(Shanghai), NSRF (Hefei), SXFEL&SHINE (Shanghai), HEPS(Beijing), HALS(Hefei), etc.
- India: Indus-II(Indore), Kolkata
- Japan: PF&PF-AR (Tsukuba), UVSOR(Okazaki),AICHI SR (Seto), RITUMEI SRC (Kusatsu), SPring-8, SPring-8-II, SACLA, NEW SUBARU (Harima), HiSOR (Hiroshima), Kyushu SR (Tosu), SLiT (Sendai)
- Korea: PLS-II, PAL-XFEL (Pohang)
- Singapore: SSLS (Singapore)
- Taiwan: TLS, TPS (Hsinchu)
- Thailand: SPS (Nakhon Rat.) , SPS-II (Rayong)




PLS-II
TLS/TPS
SPring-8
SSRF
AS
3GeV Project in Tohoku
HEPS
SPS-II
HALS

The 3rd Generation Light Sources in Asia/Oceania

Facility	Location	Energy	Emittance	Next step	Note
In operation					
Spring-8	Harima, Japan	8.0 GeV	3.0 nm	Spring-8-II	
SSRF	Shanghai, China	3.5 GeV	3.9 nm	19 more beamlines	2016-2022
Australian Synchrotron	Clayton, Australia	3.0 GeV	10.5 nm		
PLS-II	Pohang, Korea	3.0 GeV	5.8 nm		
TPS	Tsinchu, Taiwan	3.0 GeV	1.6 nm	Phase-II Beamlines	2020 -
TLS	Tsinchu, Taiwan	1.5 GeV	22 nm		
New projects					
Tohuku Light Source	Sendai, Japan	3.0 GeV	1 nm	Kickoff: 2019.3	
HEPS	Huairou, China	6.0 GeV	< 60 pm	Kickoff: 2019.6	
SPS-II	Rayong, Thailand	3.0 GeV	~ 1 nm	Approved 2019.1	
HALS	Hefei, China	2.4 GeV	< 30 pm	R&D underway	2021

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SACLA, an 8 GeV XFEL facility
• User operation since March 2012
SPring-8, an 8 GeV 3rd Gen. SR facility
• User operation since Oct. 1997
Courtesy: T. Ishikawa

Concept of SPring-8-II
- Sustainable high performance source -

Dramatic reduction of power consumption

- Lowering beam energy (8GeV → 6GeV)
- Permanent-magnet dipole
- Shutdown of existing ring injector

Advanced accelerator technology and operational experiences

- Multi-bend achromat (MBA) lattice achieving ultra-low emittance
- Short period undulator
- Beam injection from SACLA linac
- Experiences on top-up operations and orbit stabilization

World's top-level performance

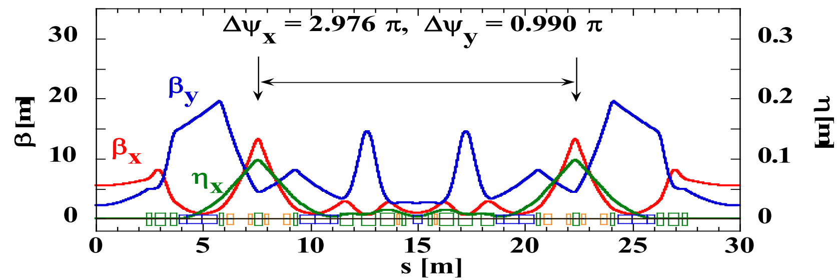
- Dramatic brilliance enhancement
- Brighter hard X-rays
- Ultimate beam stability

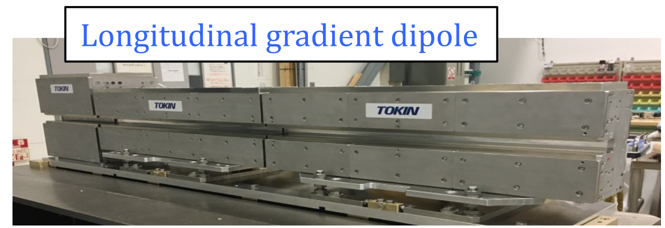
SPring-8: **3rd gen. SR** → SPring-8-II: **High coherence SR source** → SPring-8-III: **Coherent ring source**

Courtesy: H. Tanaka

Spring-8-II: main machine parameter, unit cell, prototyping

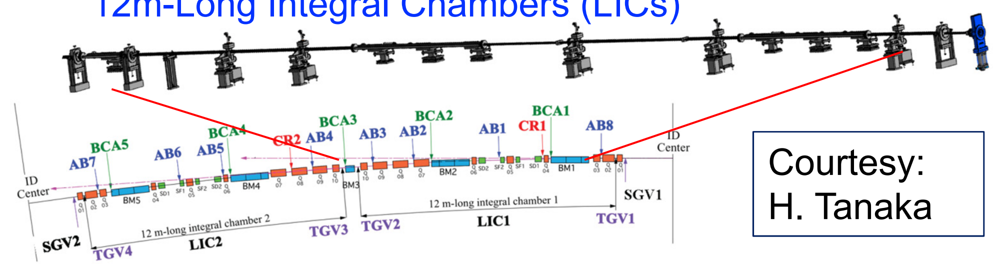
	SPring-8-II
E [GeV]	6
I [mA]	200
C [m]	1435.45
Lattice	5BA (w/ Long. Var.)
ε [nmrad]	0.157~0.10 w/ und
(β_x, β_y) [m] @ ID	(5.5, 2.2)
η_x [m] @ ID	0.0
(ν_x, ν_y)	(108.10, 44.58)
$(\xi_x, \xi_y)_{natural}$	(-143, -147)
α	3.24e-5
$\sigma_{\Delta p/p}$ [%]	0.093
κ [%]	10
h	2436
f_{RF} [Hz]	508.76
ΔU [MeV/turn]	2.96





Permanent magnet (PM) based dipoles

12m-Long Integral Chambers (LICs)



Courtesy:
H. Tanaka

Courtesy:
H.S. Kang

PLS-II upgrade project: Overview

○ **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

○ **Important improvements**

- In-vacuum undulator development
- PAL-DCM development
- New instrumentations: Libera BPM, etc.
- Superconducting RF system

PLS

PLS

Dismantling

DEC. '10

Re-installation

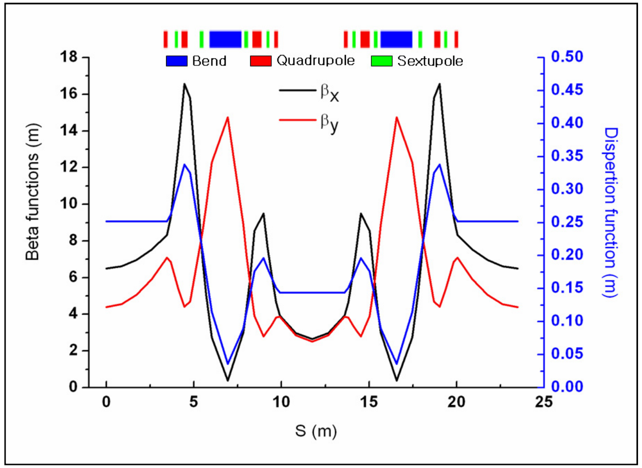
JAN. '11

PLS-II

PLS-II

Courtesy:
H.S. Kang

PLS-II storage ring



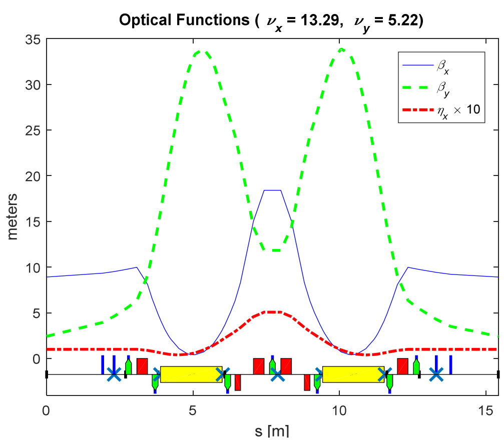
- **Beam Energy** 3.0GeV
- **Beam Current** 400mA
- **Lattice** DBA
- **Superperiods** 12
- **Emittance** 5.8 nm·rad
- **Tune** 15.37 / 9.15
- **RF Frequency** 499.97 MHz
- **Circumference** 280 m

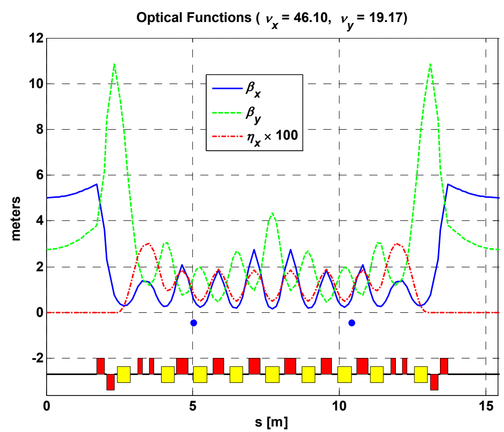
Courtesy:
H.S. Kang

Australian Synchrotron

- User operations since 2007 with 9 beamlines.
- 100 MeV s-band linac and 3 GeV FODO lattice booster ring.
- 3 GeV double-bend storage ring.
- Current projects:
  - 2019 - 2021 NLK Injection Project (R. Auchettl, WEPM001)
  - Exploring Low-emittance machine upgrade.

Parameters	DBA
E_0	3 GeV
Circumference	216 m
Straight Lengths	4.6 m
RF Frequency	499.677 MHz
I_0	200 mA
Emittance	10.5 nm
ID Beamsize (H/V)	320 / 16 um
Dipole beamsize (H/V)	87 / 58 um
1.0 keV Coh. Frac. Straight	0.02 %
10.0 keV Coh. Frac. Straight	0.0003 %

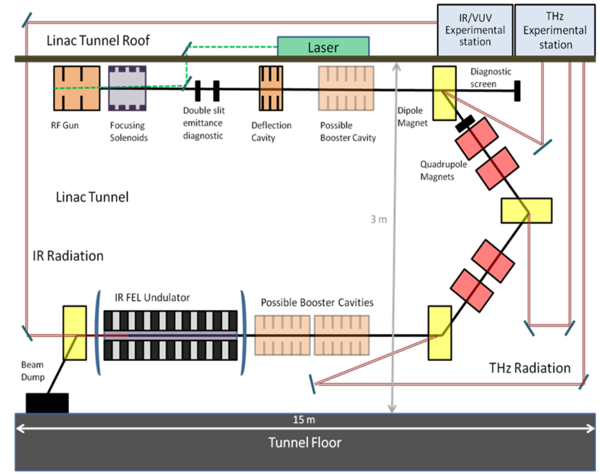


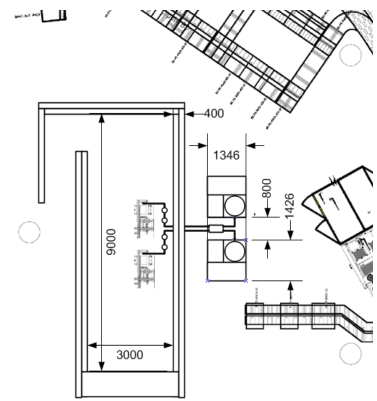


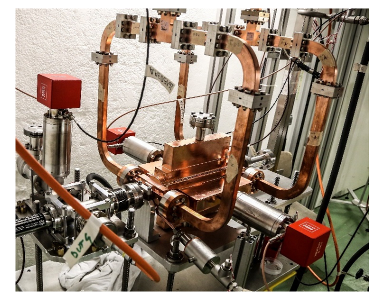
Courtesy: E. Tan

Australian Synchrotron

- Concept: THz FEL in Linac tunnel (R. Dowd)
  - Coherent Low Emittance Accelerator Radiation (CLEAR)
  - 20 MeV electrons, $\tau = 200$ fs, ~1 nC, >10 Hz rep-rate
  - Dipole CSR: up to 2 THz (60 cm^{-1}).
  - FEL: 40 to 400 cm^{-1}.
- Australian Accelerator Test Facility (AATF)
  - Bunker proposed to be built on site by 2022
  - Facilities to cater for research into for compact particle accelerators for the Australian community.







E.g. CLiC cavities

Courtesy:
E. Tan


SSRF (Shanghai Synchrotron Research Facility)
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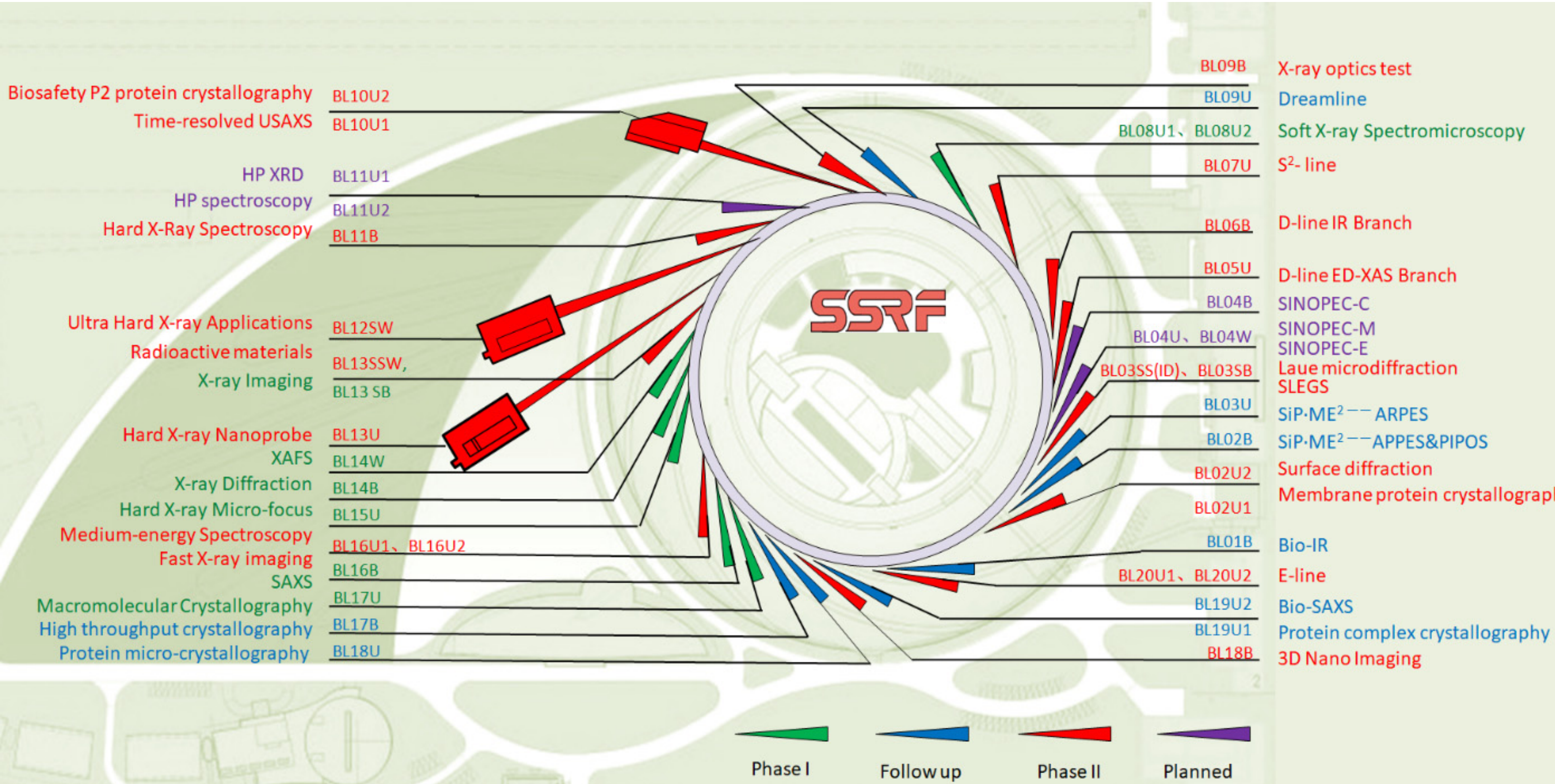
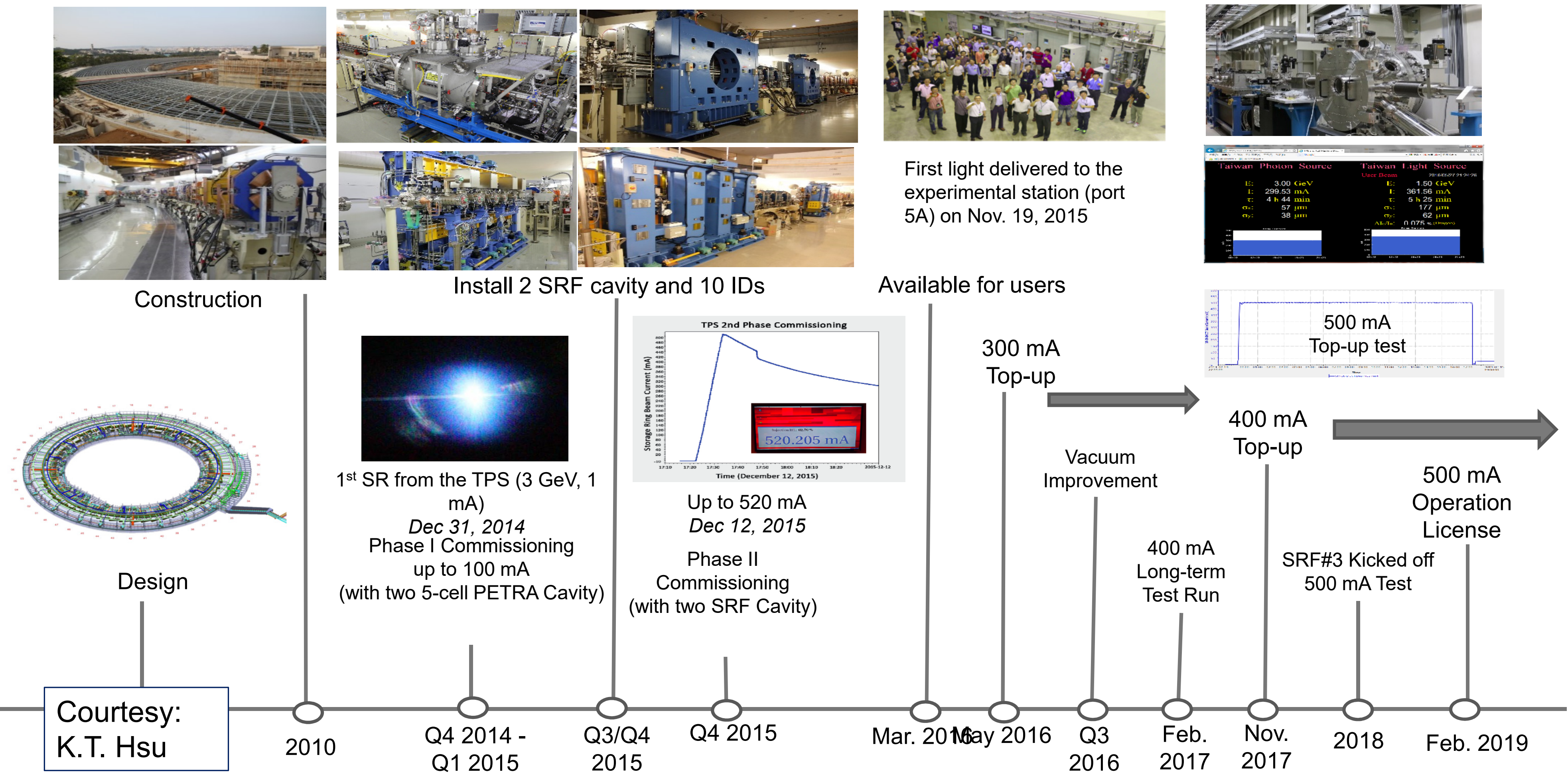
SSRF: more beamlines

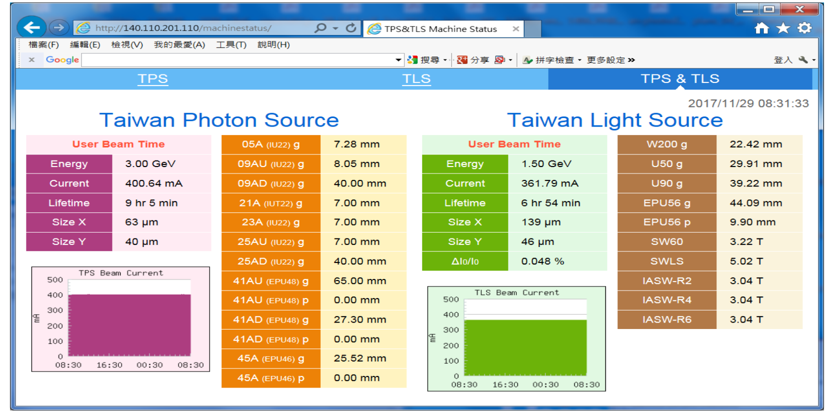


TPS Milestones



Aerial view of NSRRC campus

Operate two light sources simultaneously: TLS (1.5 GeV) and TPS (3 GeV)

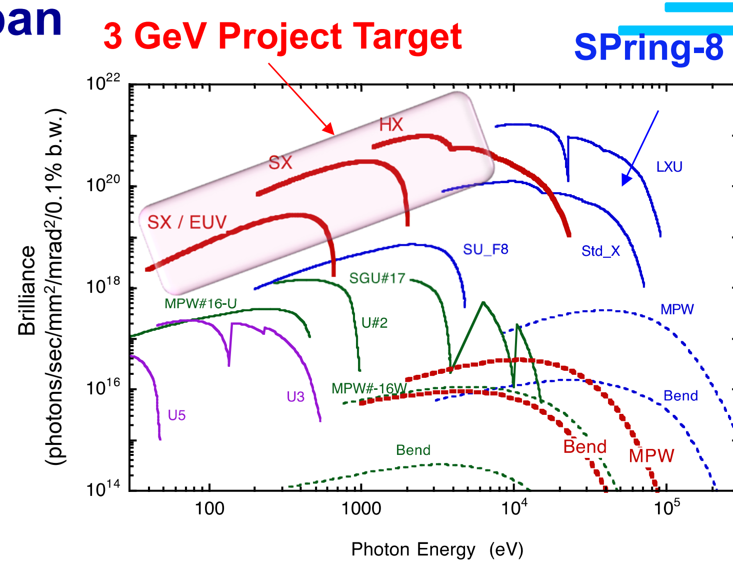


- ➢ Increase stored beam current from 300 mA in 2016 to 400 mA in late 2017 in top-up operation. The 500 mA operation is scheduled。
- ➢ Construct 3rd SRF system (2018 ~ 2022) to accommodate more than 20 sets of insertion devices operated at 500 mA. Improve reliability under more comfortable operation conditions.
- ➢ Upgrade analogue LLRF to digital LLRF for booster and storage ring RF systems.
- ➢ Prepare 7 sets of IDs for Phase II beamlines (3 produced in-house, 2 CPMU co-developed with vendor, 2 procured from vendor).
- ➢ 7 Phase I beamlines and 3 Phase II beamlines available now. 3 Phase II beamlines will available in 2020.

Courtesy: K.T. Hsu

Concept of 3 GeV light source in Tohoku, Japan

- Highly brilliant compact Soft X-ray source with supreme stability and reliability
- SXFEL in future upgrade



Design strategy

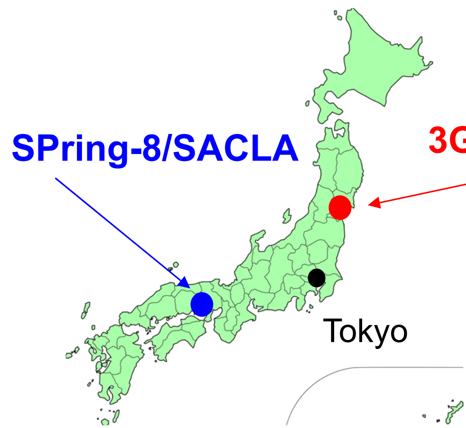
- User oriented light source: not a test accelerator
- Design based on full-fledged accelerator technology developed at SPring-8/SACLA
- Short straight sections for MPW HX source
- Full energy injector linac for future SXFEL driver

Complementary partner of SPring-8

Target performance for SX (1 - 3 keV)

- Brilliance >10^{21} photons/sec/mm2/mrad2/0.1% b.w.
- Coherent ratio R ~ 10 %

- I= 400 mA, ε= 1 nm.rad

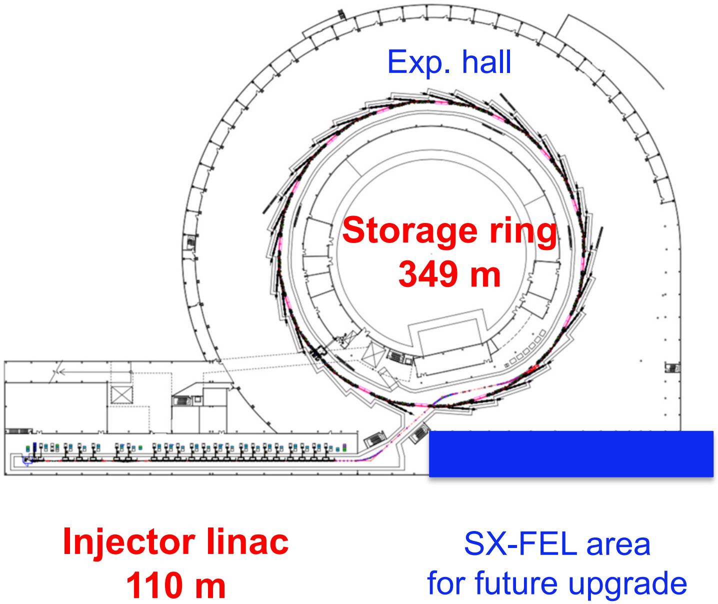


First light expected in FY2022

Courtesy:
N. Nishimori

Accelerator design

3 GeV accelerator

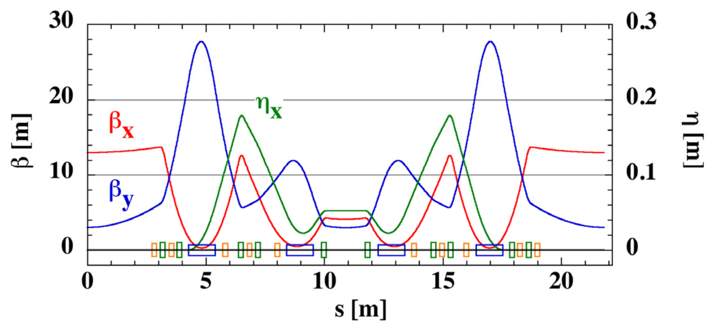


Storage ring parameters

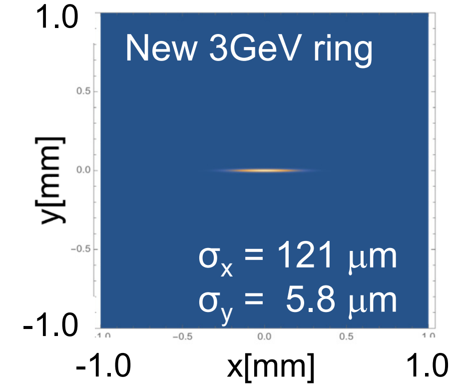
Beam energy	3.0 GeV
Stored current	400 mA
Lattice	4B-achromat
Circumference	348.8 m
Number of cells	16
Natural emittance	1.1 nm.rad
Energy spread	0.084 %
Beam size σ_x / σ_y @ ST	121 / 5.8 μm

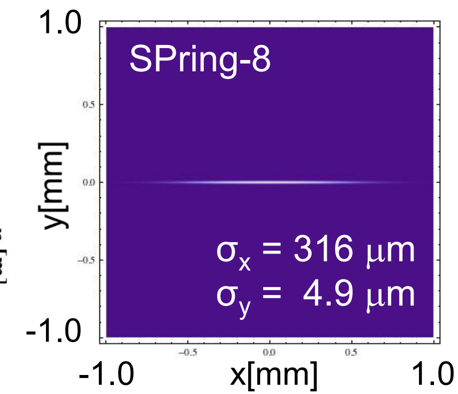
※ Coupling = 1 %

4 bend achromat lattice



Beam size at undulator



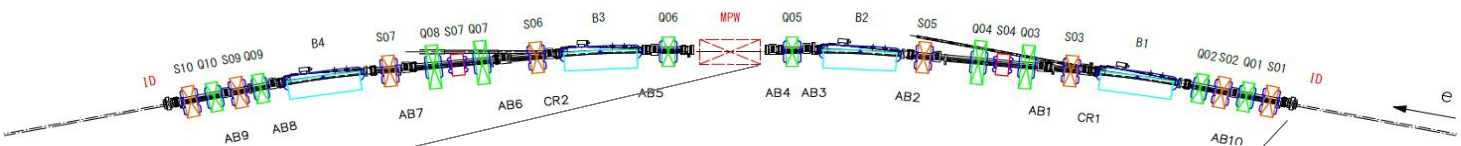


Courtesy:
N. Nishimori

Storage ring development taking advantage of R&Ds for SPring-8-II

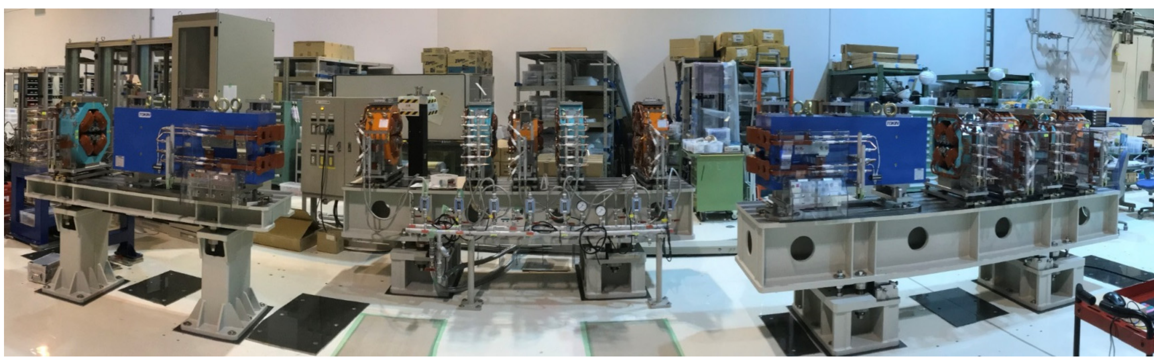
- Test half-cell constructed to study magnet performance and to establish precise alignment procedures
- Narrow-aperture vacuum chambers made of stainless steel
- HOM-damped TM020 RF cavity under high-power test
- Ring beam injection system with in-vacuum transparent off-axis scheme under development

3GeV storage ring unit cell (4 bend achromat lattice)

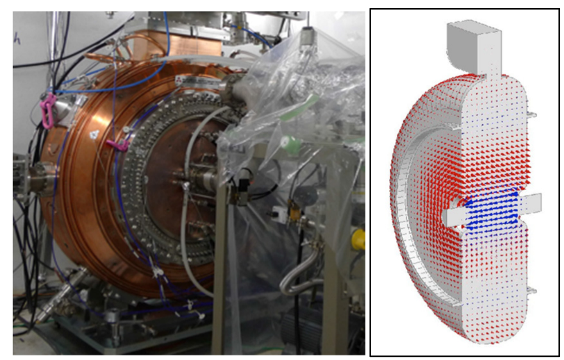


Courtesy:
N. Nishimori

Test half-cell composed of 2 combined-B, 5Q, 5SX



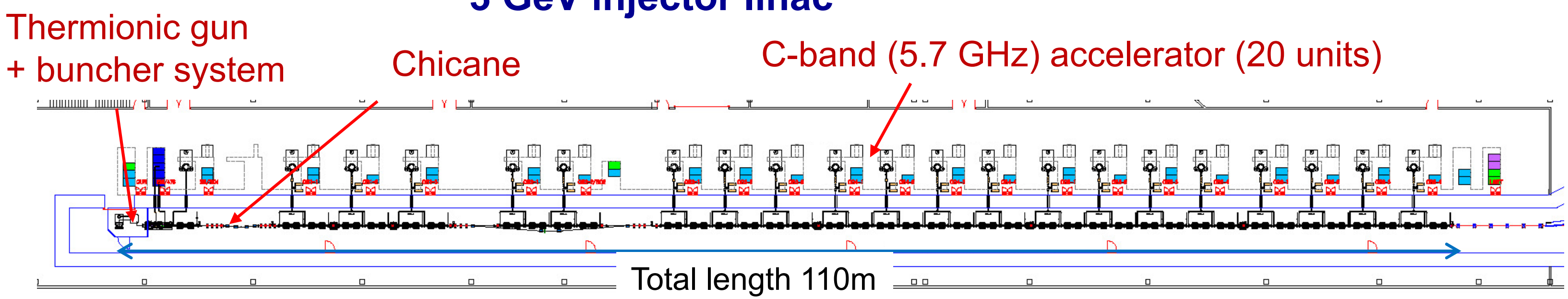
HOM-damped TM020 RF cavity



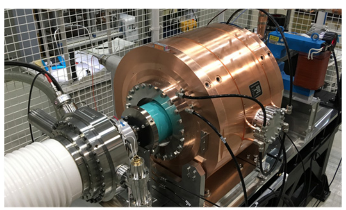
Injector linac development by technologies of SACLA for reliability and cost reduction

- C-band accelerator system (42MV/m) developed at SACLA with some modifications
- A new thermionic gun system for low cost and high reliability
- Future extension to SXFEL by gun replacement

3 GeV injector linac

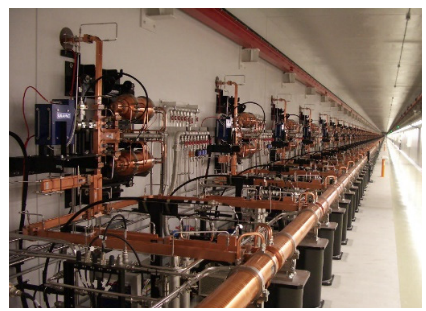


A new gun system



Courtesy:
Nobuyuki Nishimori

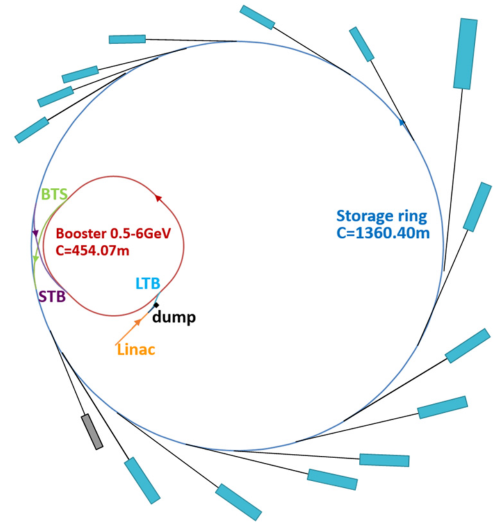
C-band accelerator at SACLA



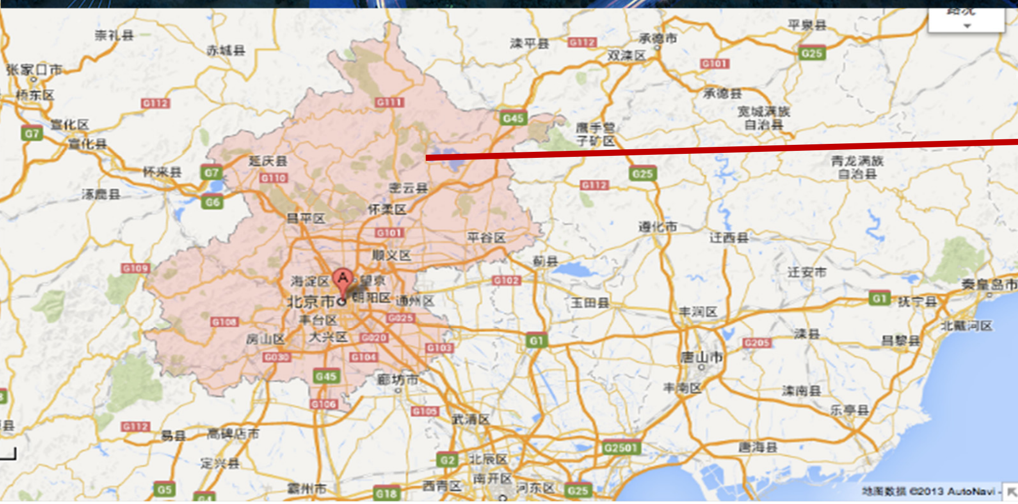
3GeV linac parameters

Parameter		
Beam energy	E (GeV)	3
Normalized emittance	(μmrad)	<10
Emittance at 3 GeV	(nmrad)	<1.7
Bunch charge	(nC)	0.3
Repetition rate (Normal)	(Hz)	1

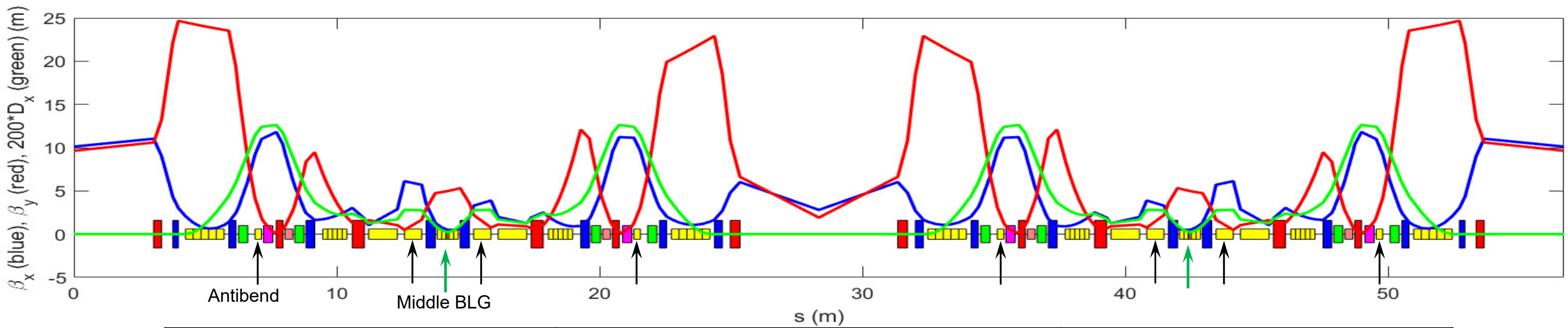
HEPS:
High Energy Photon Source



Courtesy: Q. Qin



HEPS: Lattice design of storage ring & main parameters



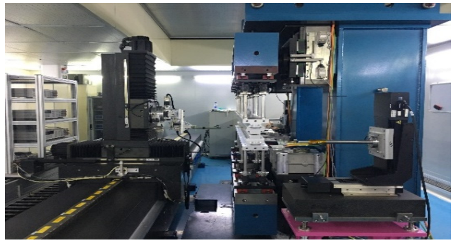
Beam energy	GeV	6
Circumference	m	~1360
Current	mA	200
H. natural emittance	nm·rad	≤ 0.06
Bunch length	mm	3~36
Brilliance	Pho/s/mm^2/mrad^2/0.1%BW	> 10^{22}
Injection		Top-up

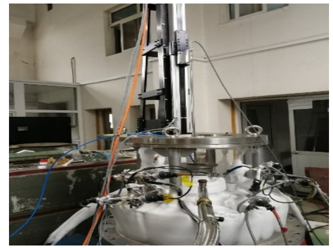
Courtesy:
Y. Jiao

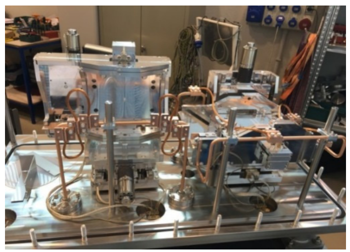
HEPS: Key technologies developed in R&D

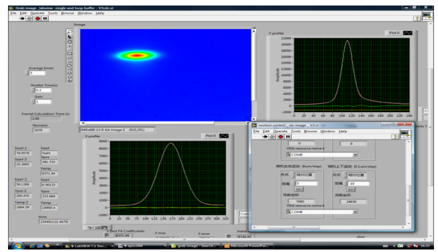
- CPMU, 166 MHz SRF cavity
- Digital BPM electronics, KB mirror system
- Fast kicker and power supply, high precision girder

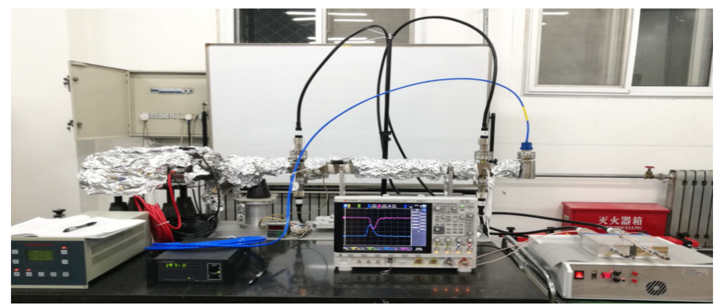
Ground breaking next month!



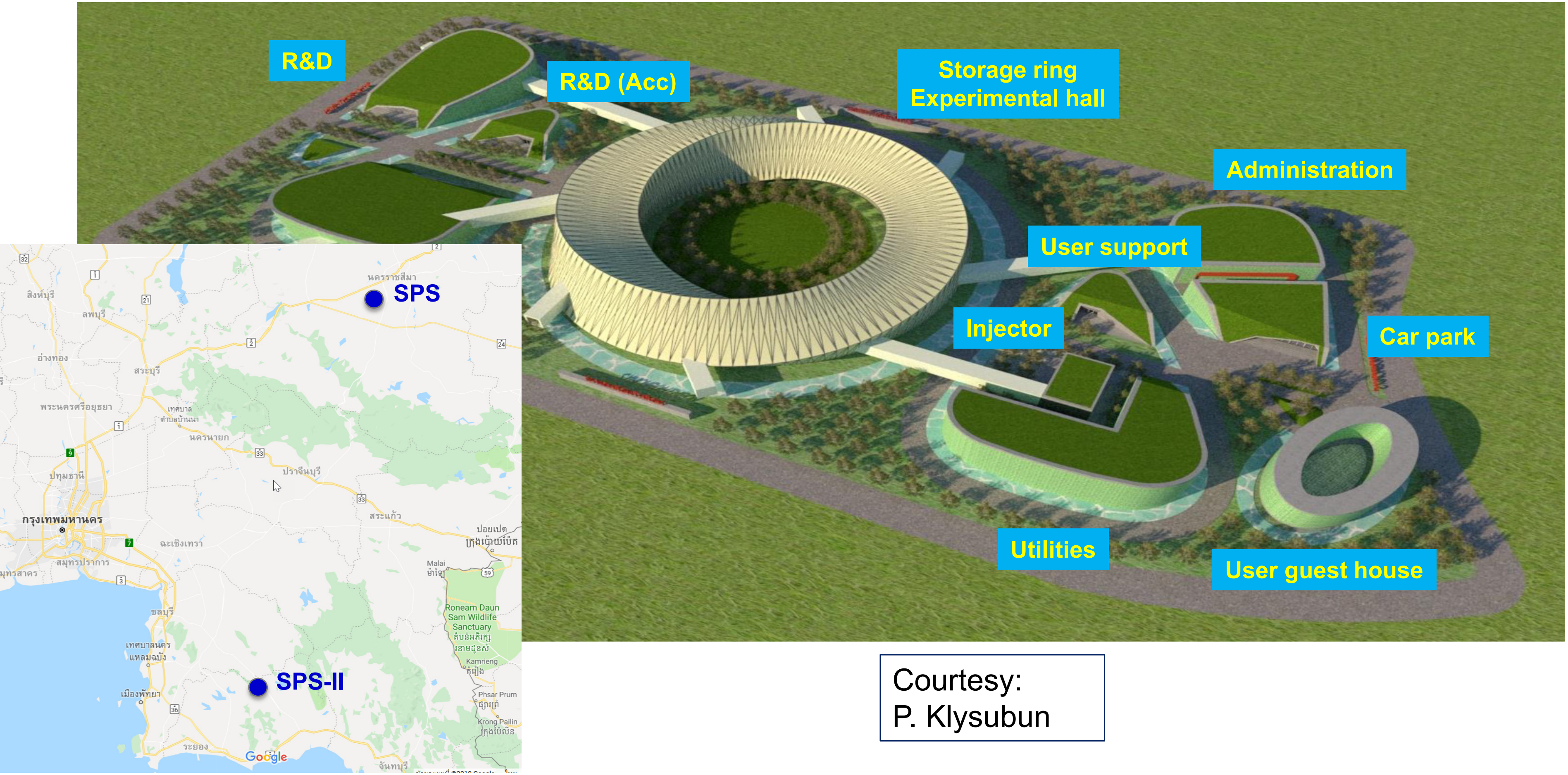






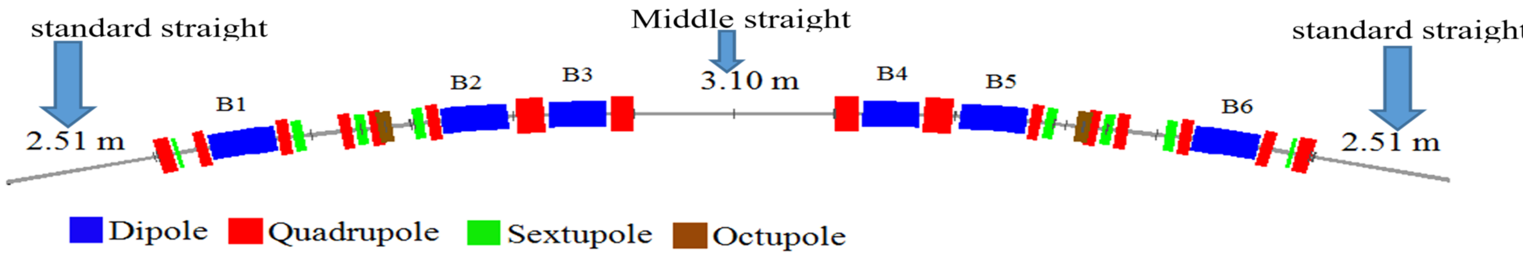


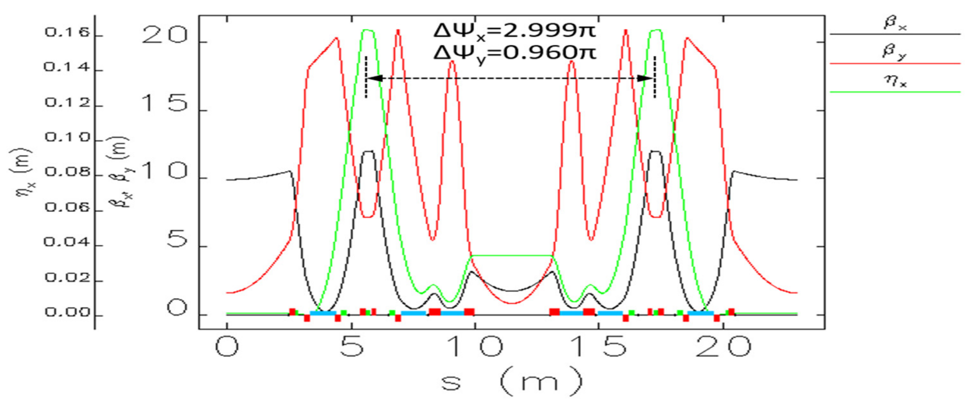
SPS-II complex, Rayong, Thailand



Courtesy:
P. Klysubun

SPS-II : storage ring lattice





DTBA lattice

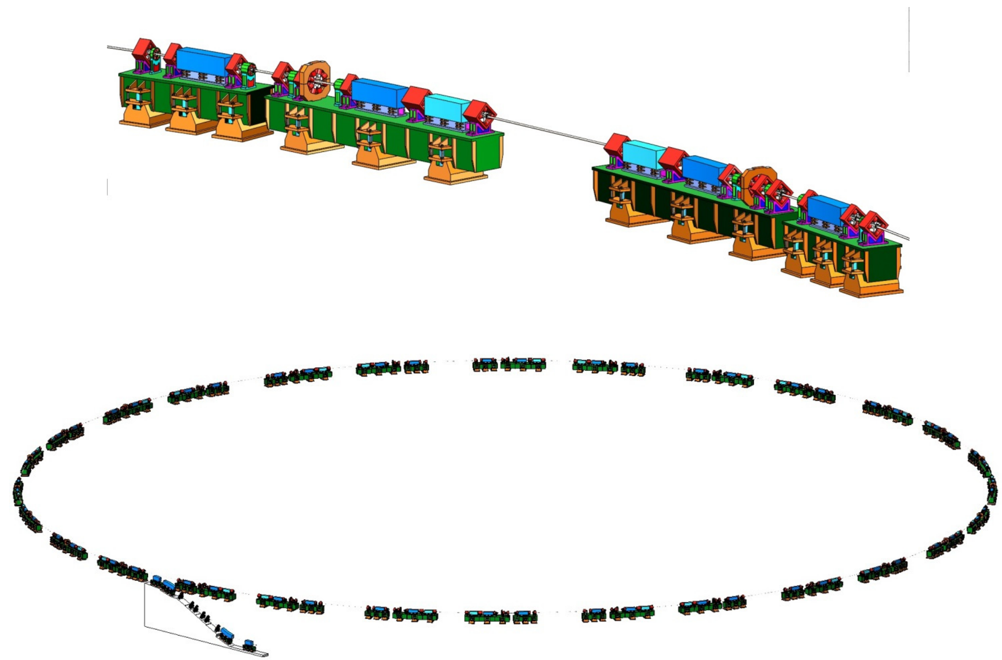
- 14 DTBA cells (22.95 m/cell)
- Total circumference 321.3 m
- Total 28 straights:
  - 14 standard straights of 5.02 m
  - 14 middle straights of 3.10 m
- Utilize combined function dipoles (B3 and B4)

Double Triple Bend Achromat (DTBA) lattice (Modified 6BA)

Courtesy:
P. Klysubun

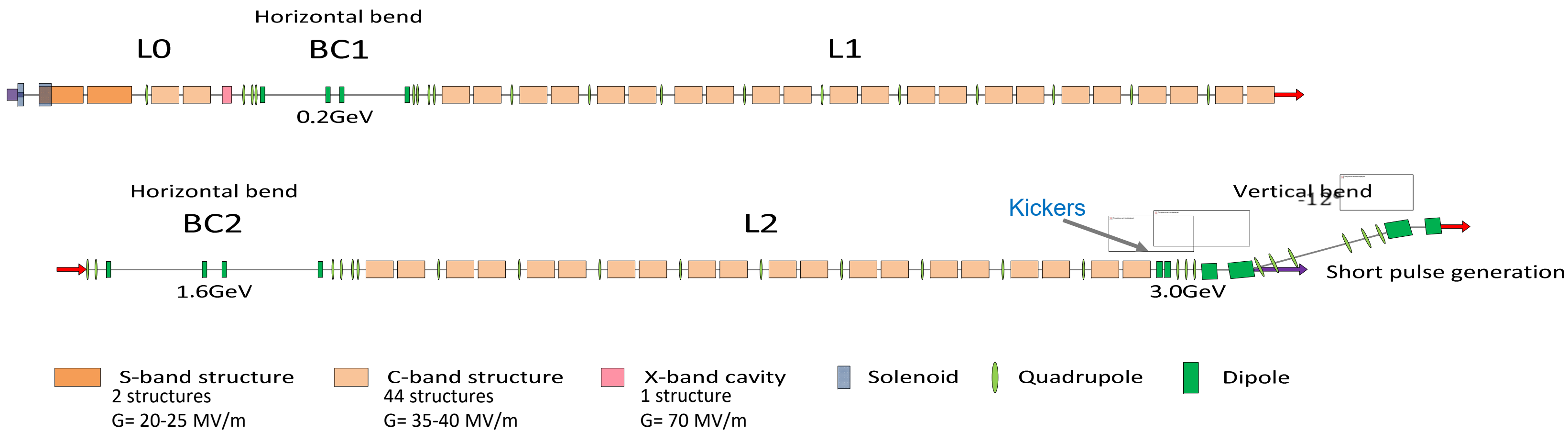
SPS-II storage ring: Main parameters

Store beam energy	3.0 GeV
Beam current	300 mA
Emittance	0.96 nm-rad
Lattice structure	DTBA
Superperiods	14
Circumference	321.3 m
Radio frequency	500 MHz
Long straight section length	5.02 m x 14
Short straight section length	3.10 m x 14
Number of cavities	6
RF voltage	2.2 (3.6) MV
Harmonic number	536
Betatron tunes (ν_x, ν_y)	34.241, 12.310
Chromaticities (ξ_x, ξ_y)	+2, +2



SPS-II storage ring

SPS-II: full energy injector linac



Main features

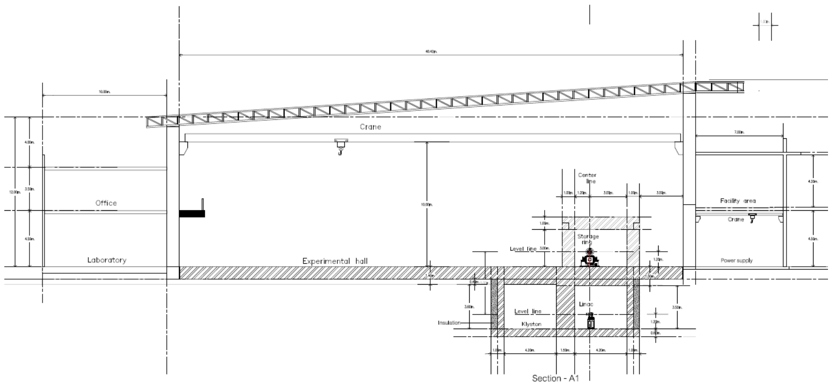
- Laser-induced photocathode RF gun
- Based on C-band, NC technology for main linacs
- Two bunch compressors at 200 MeV and 1.6 GeV
- Total linac length 170 m
- Built in the underground tunnel

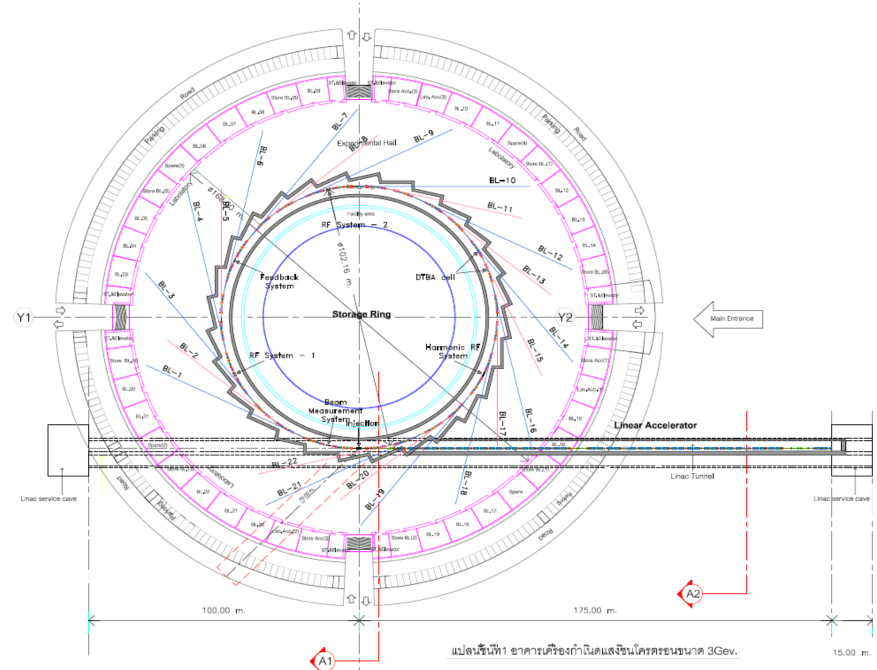
Linac operation

- Injection mode: without bunch compression by adjusting C-band phase
- Full operation mode: with compression + deliver short bunches to storage ring

Parameters	Value
Total injector length	170.5 m (linac:155m + TL:15.5m)
Electron beam energy	3.03 GeV
Repetition rate	60 Hz
Bunch charge	1 nC
Normalised emittance ε_{nx}	<10 µm·rad
Energy spread σ_E	<1 %
Bunch length	Injection: <10 ps (3 mm)
	Short pulse: <200 fs (60 µm)

SPS-II: main building and timeline





SPS-II CDR completed

R&D of components and technology necessary for SPS-II (magnets, vacuum, RF, electron gun, etc.)

IPAC '22 in Bangkok

SPS-II DDR completed

SPS-II groundbreaking

3 GeV linac commissioning

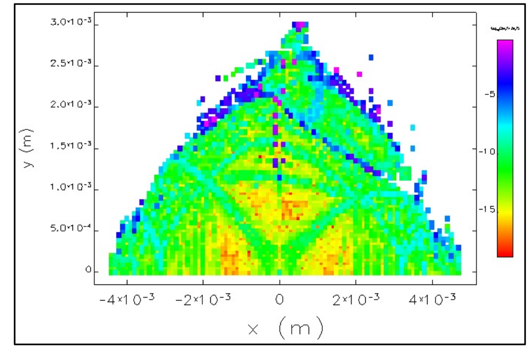
SPS-II opened to users

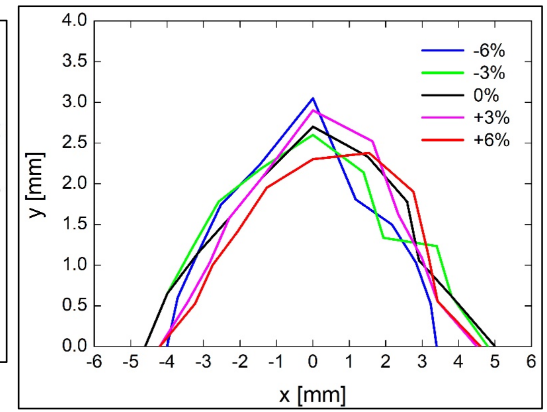
2017 2018 2019 2020 2021 2022 .... 2025 2026 2027

Courtesy: P. Klysubun

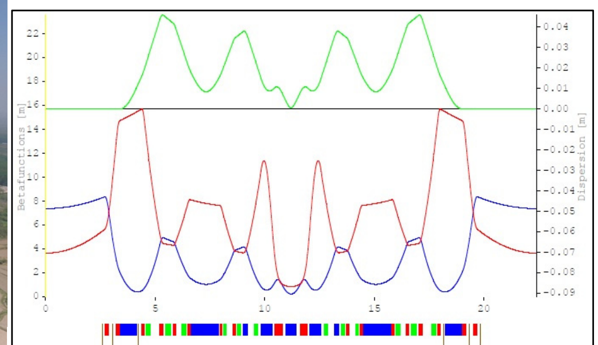
HALS (Hefei Advanced Light Source)

Parameter	Value
Energy	2.4 GeV
Circumference	672 m
Number of cells	30
Natural emittance	24.7 pm·rad
Transverse tunes	71.296, 23.296
Natural chromaticities	-97, -110
Momentum compaction	5.0×10^{-5}
Length of long straights	5.4 m

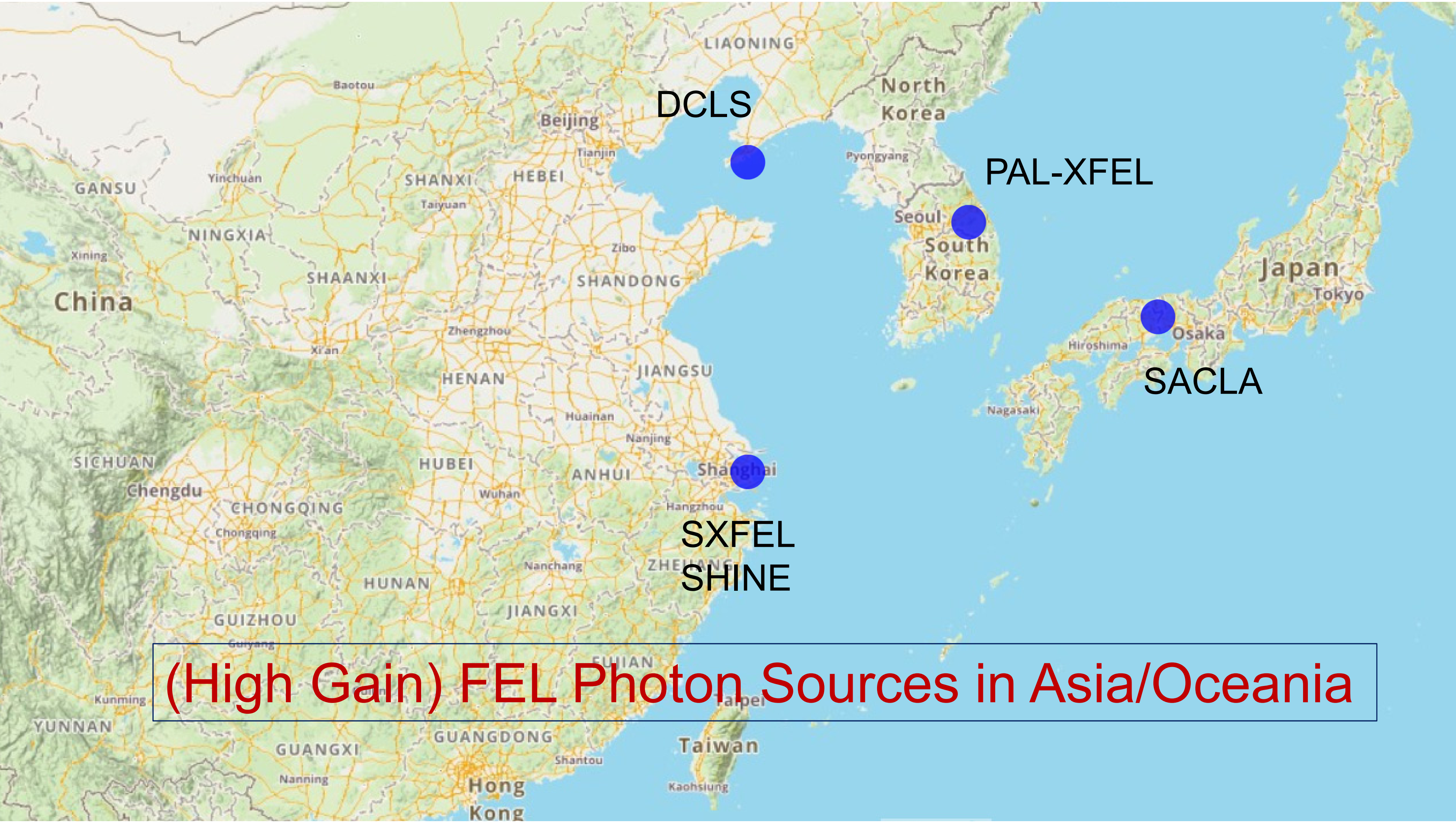




On and off mom. DA



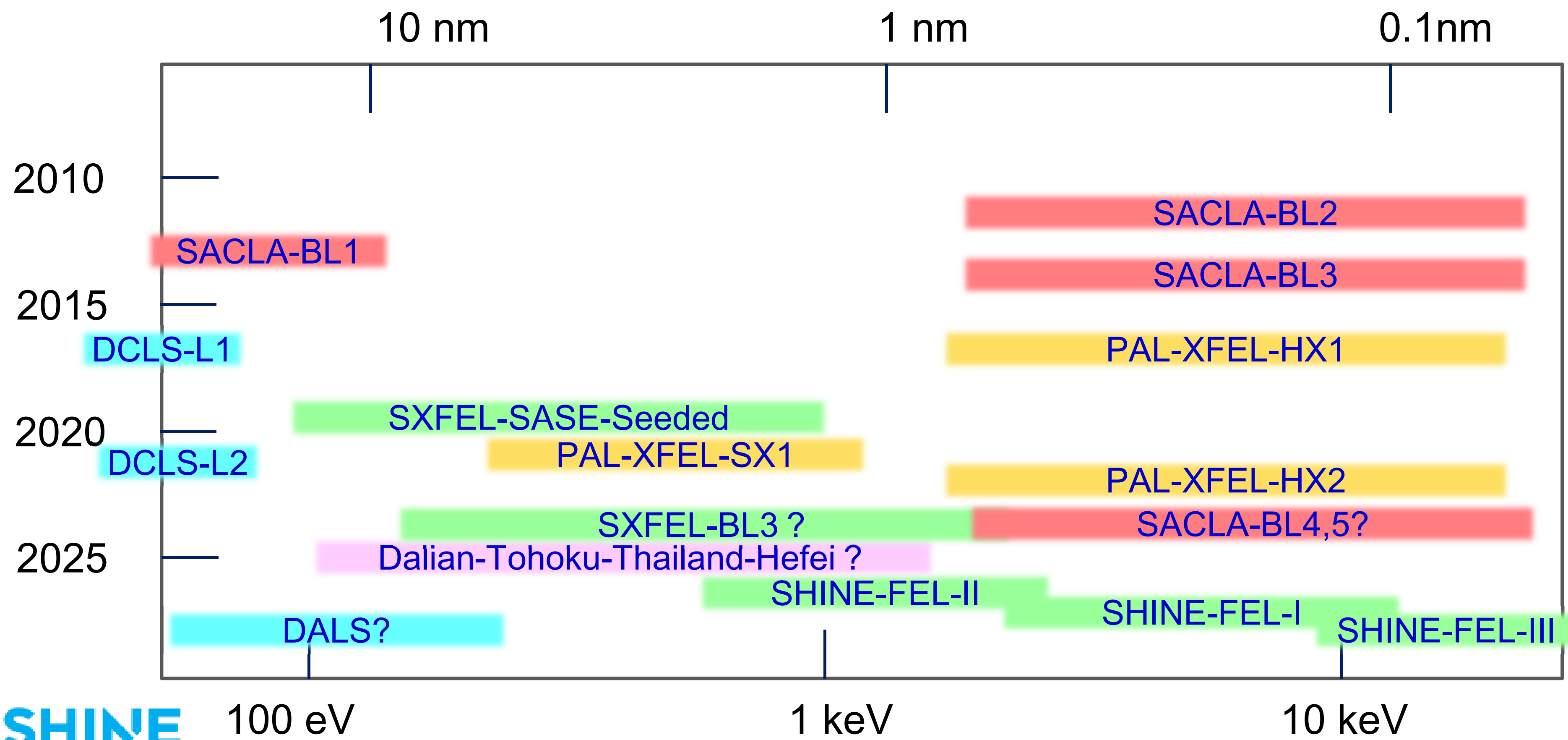
7BA lattice


DCLS
PAL-XFEL
SACLA
SXFEL
SHINE
(High Gain) FEL Photon Sources in Asia/Oceania

The High Gain Free Electron Lasers in Asia/Oceania

Facility	Location	e- Energy	Photon Energy	Status	Next
SCSS	Harima, Japan	0.3 GeV	Test bed at 10-25 eV	In SACLA	
SDUV	Shanghai, China	0.2 GeV	Test bed at 5 -10 eV	In SXFEL/LPA	
SACLA	Harima, Japan	8.0 GeV	BL2: 4-15 keV	Operation	More beamlines
			BL3: 4-15 keV	Operation	Injector for Spring-8
		0.8 GeV	BL1: 20-150 eV	Operation	
PAL-XFEL	Pohang, Korea	10.0 GeV	HX1: 2.0-14.5 keV	Operation	HX2
		3.0 GeV	SX1: 0.25-1.5 keV	Installation	Open to user in 2020
DCLS	Dalian, China	0.3 GeV	BL1: ~7-20 eV	Operation	cw VUV FEL R&D
			BL2: polar. control	Installation	Open 2020
SXFEL	Shanghai, China	0.84 GeV	~150 eV	lased	Merge to user facility
		~1.6 GeV	50 ~ 600 eV	Installation	Open to user in 2020
SHINE	Shanghai, China	8.0 GeV	FEL-I: 3-15 keV	Construction	8 years including R&D
			FEL-II: 0.4-3 keV		
			FEL-III: 10-25 keV		

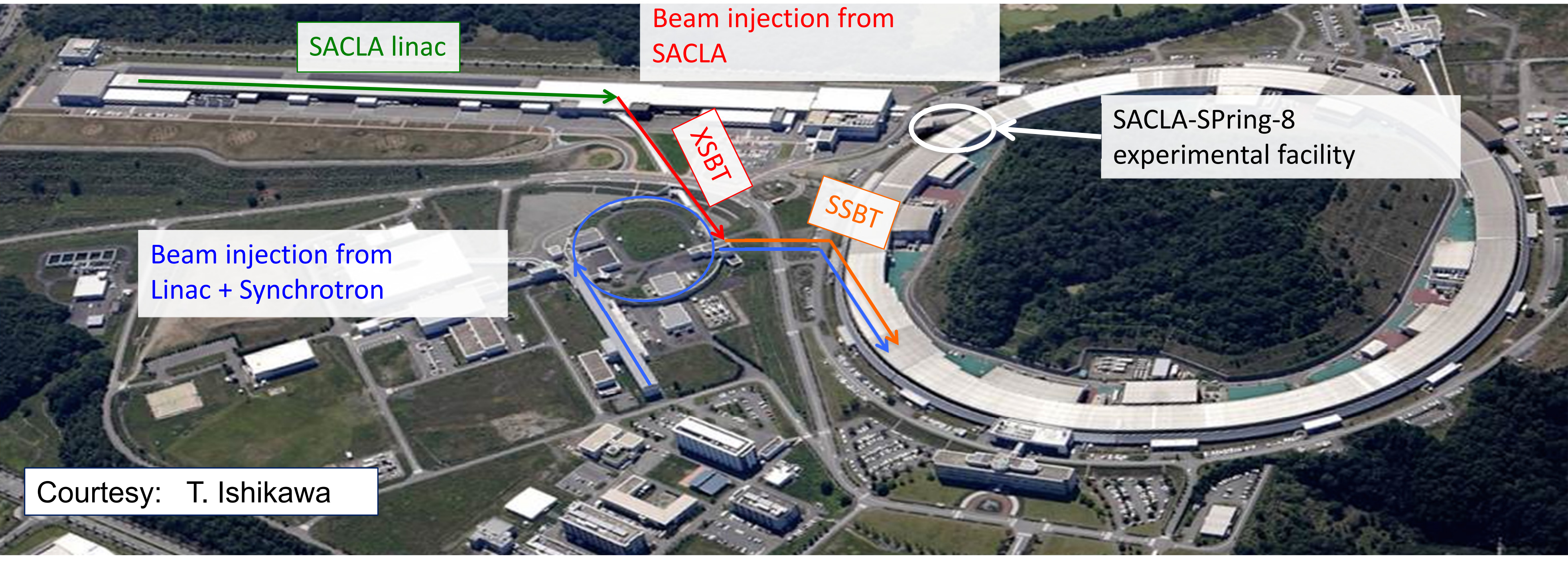
FEL light sources in Asia: timelines and photon energy ranges



SHINE

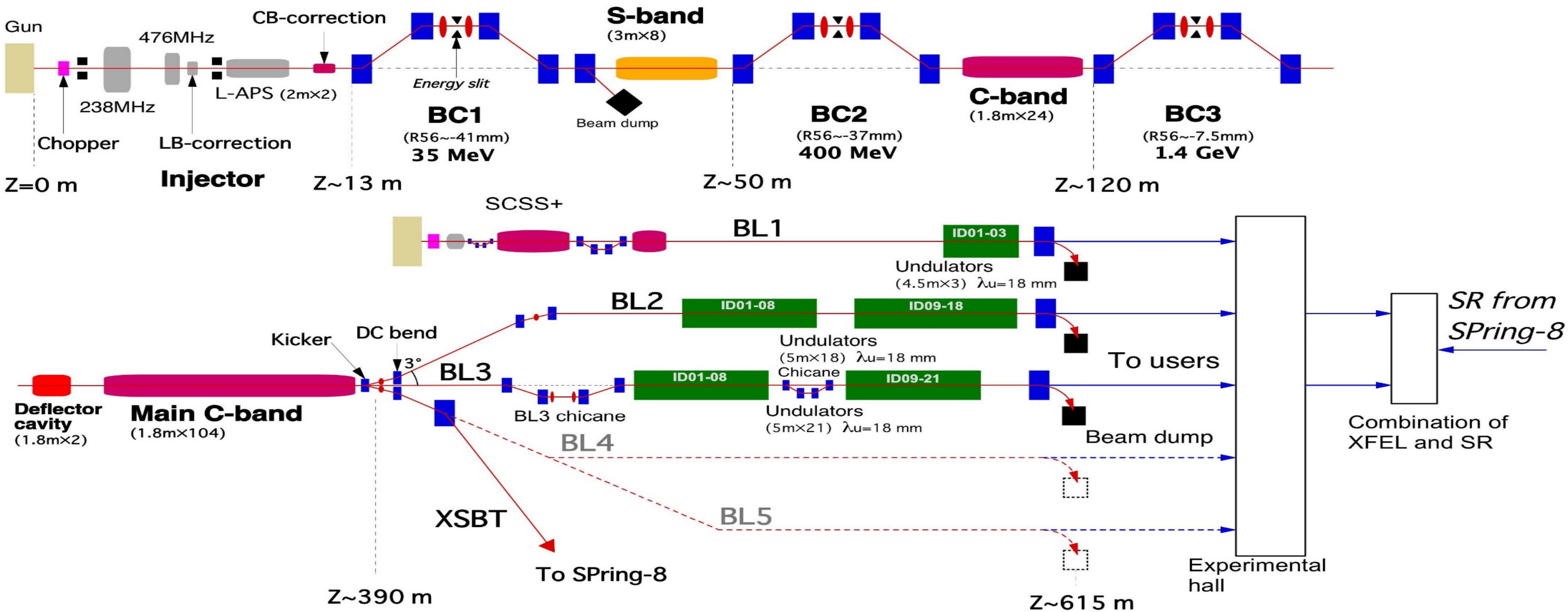
SACLA + SPring-8

- The electron beam has been successfully injected to the SPring-8 storage ring.
- Long electron bunches are used to avoid CSR effects.
- Beam injection while keeping XFEL operation is the next step.



Courtesy: T. Ishikawa

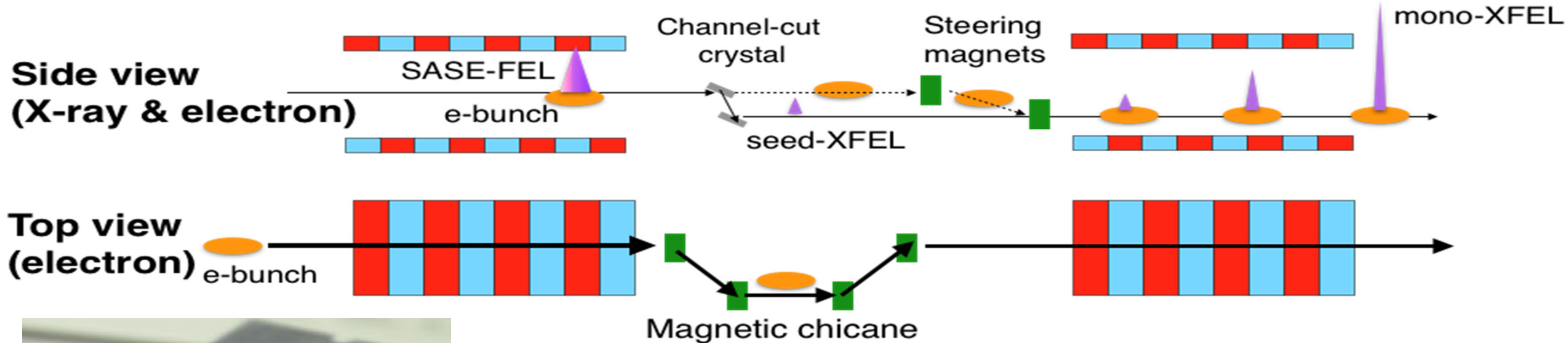
SACLA machine layout

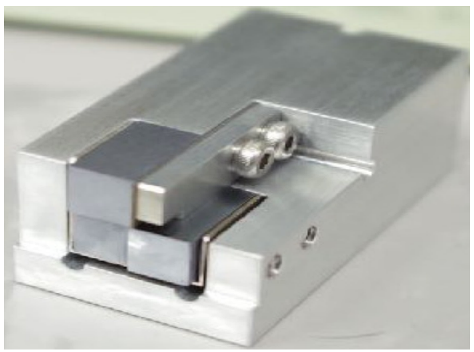


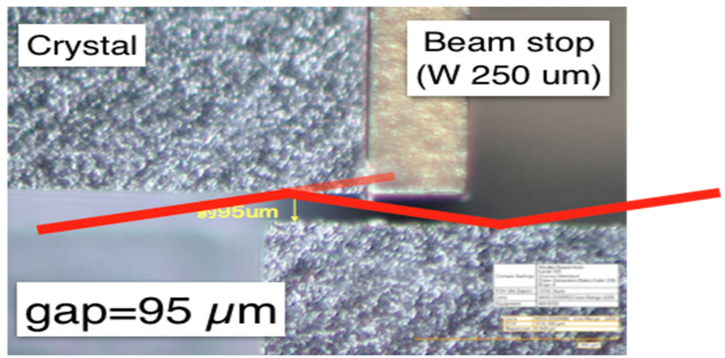
Courtesy: H. Tanaka

BL1: EUV and soft x-ray (20-150 eV)
BL2 and BL3: hard x-ray (4-15 keV)

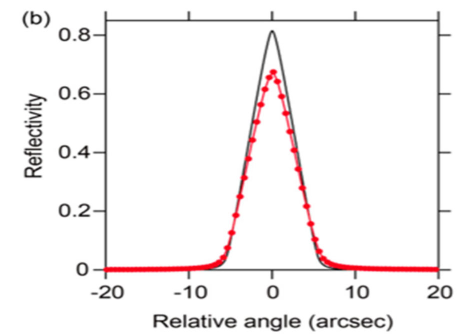
Reflection type self-seeding at SACLA BL3







Si micro-channel-cut crystal



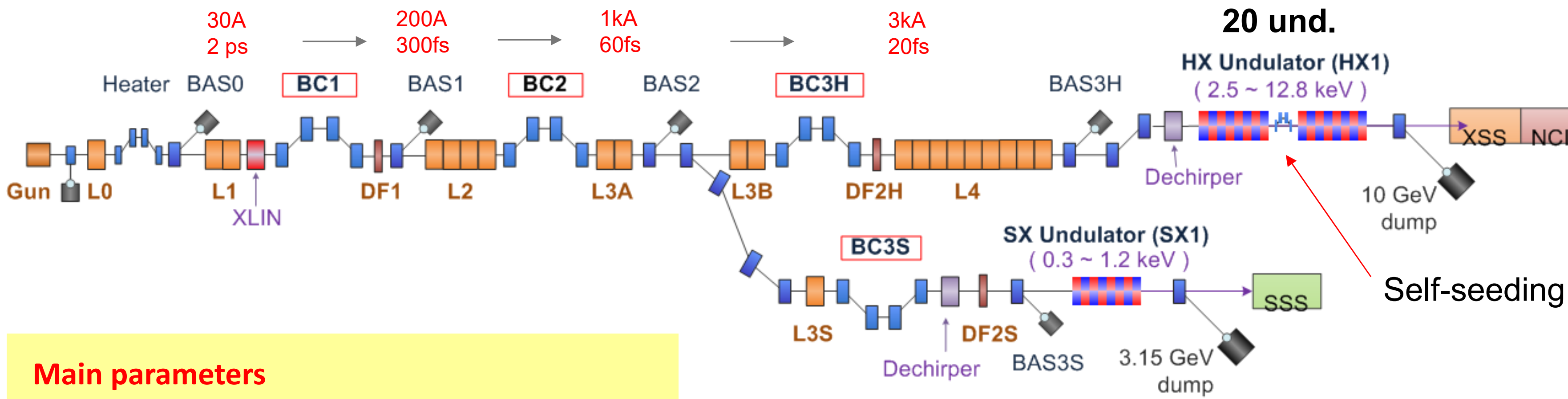
Rocking curve of Si (111) measured using 10 keV monochromatized SR.

Courtesy: H. Tanaka

(Talk by I. Inoue in IPAC2019)


PAL-XFEL
0.1 nm hard X-ray FEL using a 10 GeV normal conducting linac
Apr. 2011: PAL-XFEL project started
Jun. 2012: Ground-breaking
Dec. 2014: Building completed
Jan. 2016: Installation completed
Apr. 2016: Commissioning started
Jun. 2017: User-service started
PAL-XFEL
Profile Monitor HU1E:SCM36 16-Mar-2017 20:40:0
0.1 nm
y (mm)
x (mm)
14 Jun. 2016 First SASE lasing at 0.5 nm
28 Oct. 2016 Lasing at 0.15 nm
27 Nov. 2016 Saturation of 0.15 nm
16 Mar. 2017 Saturation of 0.1 nm

PAL-XFEL Parameters



Main parameters

e^- Energy	11 GeV
e^- Bunch charge	20-200 pC
Slice emittance	< 0.4 mm mrad
Repetition rate	60 Hz
Pulse duration	5 fs – 50 fs
Peak current	3 kA
SX line switching	DC magnet (to be changed to Kicker by 2020)

Undulator Line	HX1	SX1
Photon energy [keV]	2.0 ~ 14.5	0.25 ~ 1.25
Beam Energy [GeV]	4 ~ 11	3.0
Wavelength Tuning	energy	gap
Undulator Type	Planar, out-vac.	Planar
Undulator Period / Gap [mm]	26 / 8.3	35 / 9.0

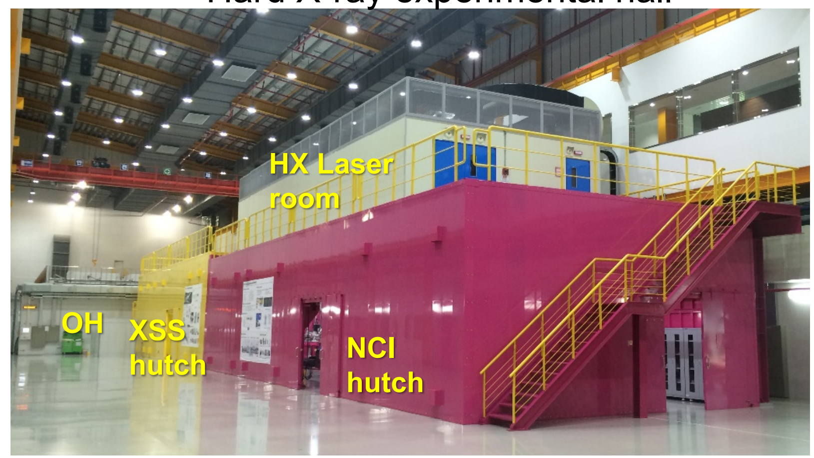
Courtesy: H.S. Kang

Klystron gallery

Linac tunnel

Undulator hall

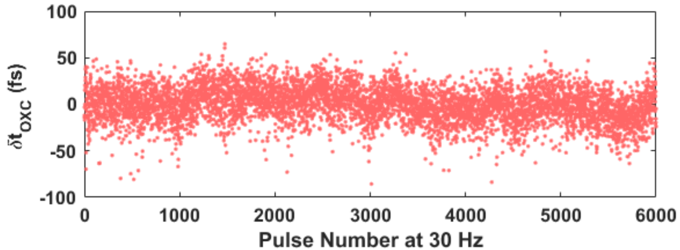
Hard X-ray experimental hall

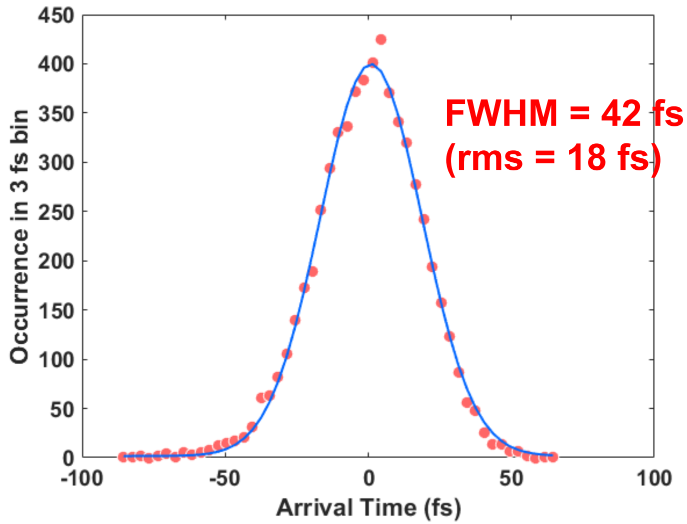


Courtesy: H.S. Kang

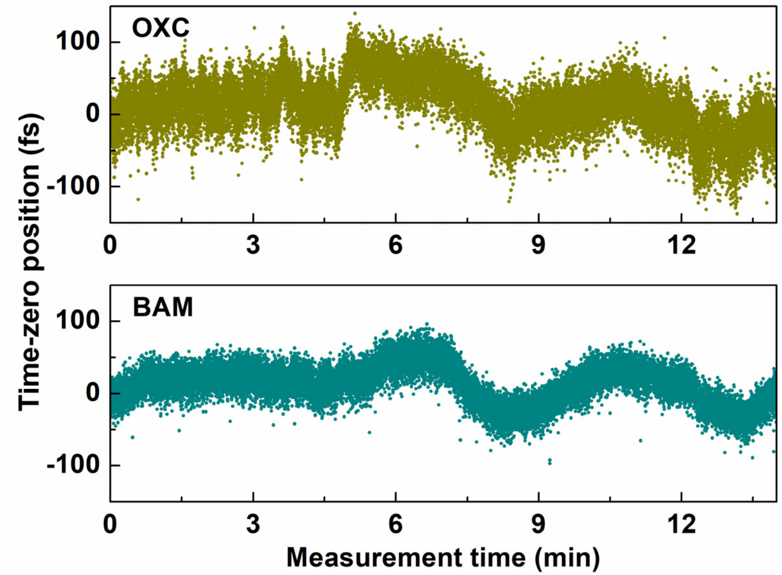
Timing jitter between XFEL and optical laser: 18 fs

Statistics for 6000 XFEL shots (30 Hz)

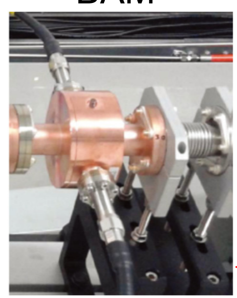




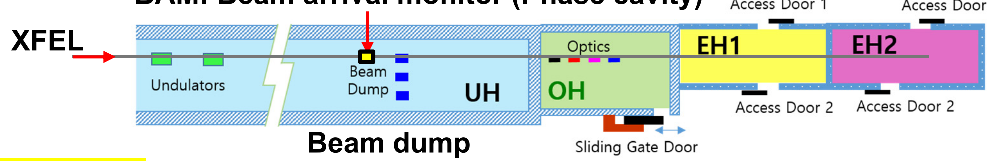
Stability for 14 minutes



BAM



BAM: Beam arrival monitor (Phase cavity)



Courtesy: H.S. Kang

best performance in the world

Dalian Coherent Light Source (DCLS)

A new source of ultraviolet beams will probe aerosols in China's notorious smog.

LIGHT SOURCES

Unique free electron laser laboratory opens in China

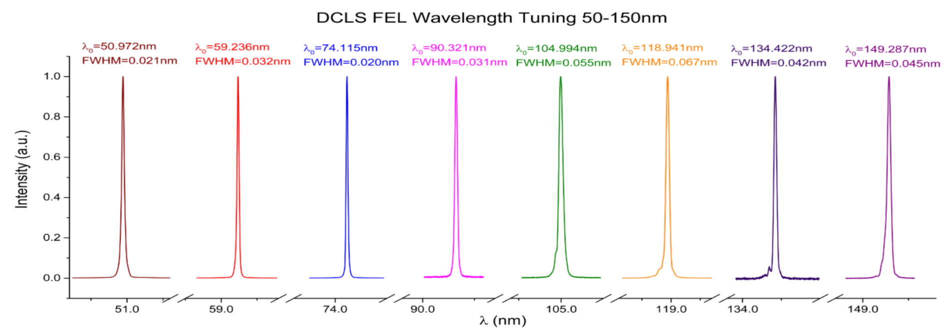
New device will probe smog and other gaseous phenomena

By **Dennis Normile**

China is joining the elite club of countries that have built the potent sources of high-energy photons called free electron lasers (FELs) for their researchers. The Dalian Coherent Light Source, whose completion was ing in Europe, Japan, and the United States produce "hard" x-ray laser beams, with wavelengths down to 0.1 nanometers, ideal for studying crystallized proteins and other solids. But the beams are so powerful "they break up molecules" in gases, says Yang Xueming, a physical chemist at the Chinese Academy of Sciences's (CAS's) Dalian Insti-

Science v355, issue 6322, p235(2017)

- Tunable Wavelength: 50 – 150 nm
- Pulse Energy: >100 uJ (1 mJ)
- Pulse length: 100 fs /1 ps
- Bandwidth: Close to FT limit
- Jitter: <30 fs
- Rep Rate: 50 Hz

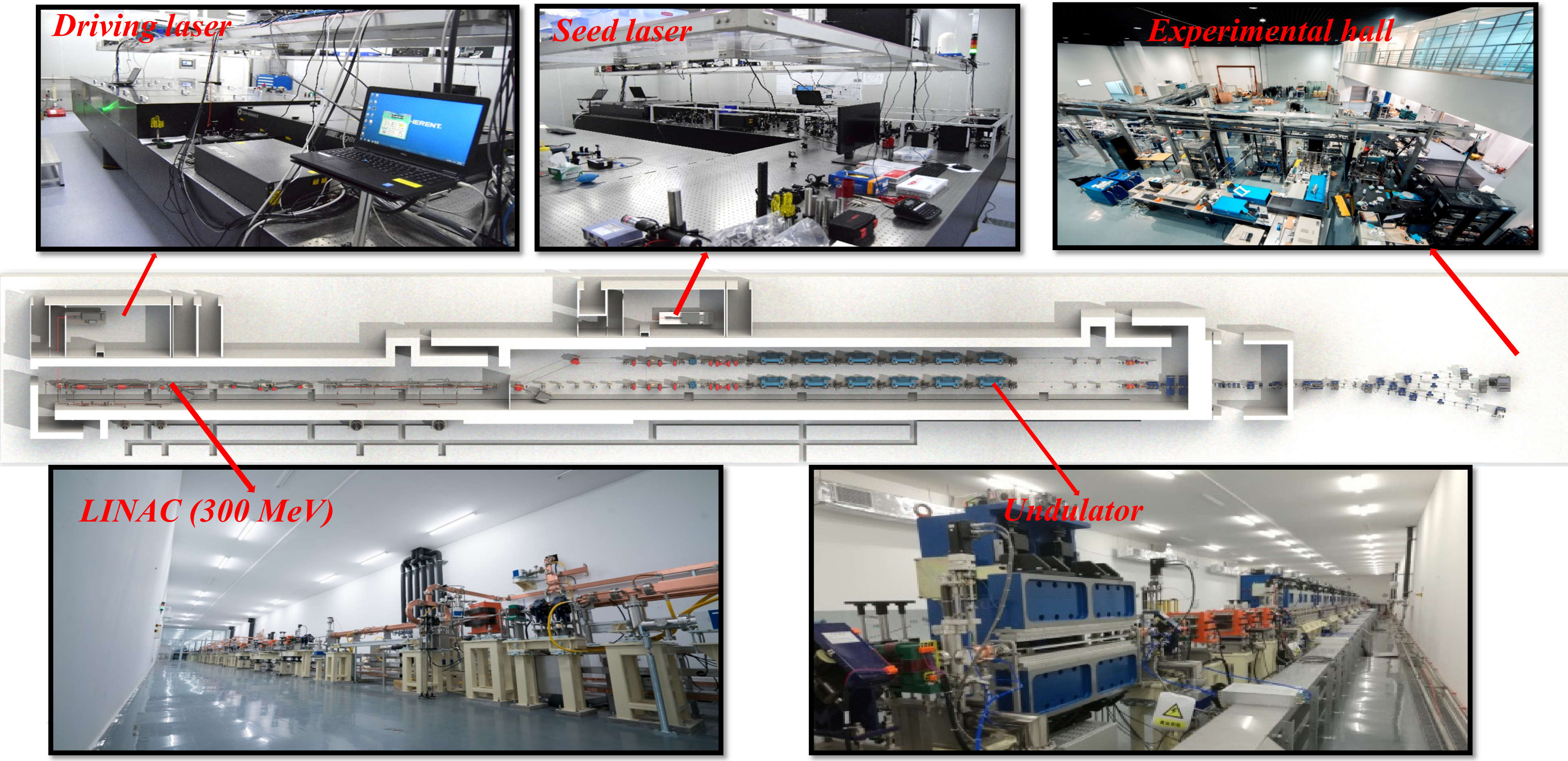


中国科学院大连化学物理研究所
DALIAN INSTITUTE OF CHEMICAL PHYSICS, CHINESE ACADEMY OF SCIENCES

SINAP 中国科学院上海应用物理研究所
Shanghai Institute of Applied Physics, Chinese Academy of Sciences

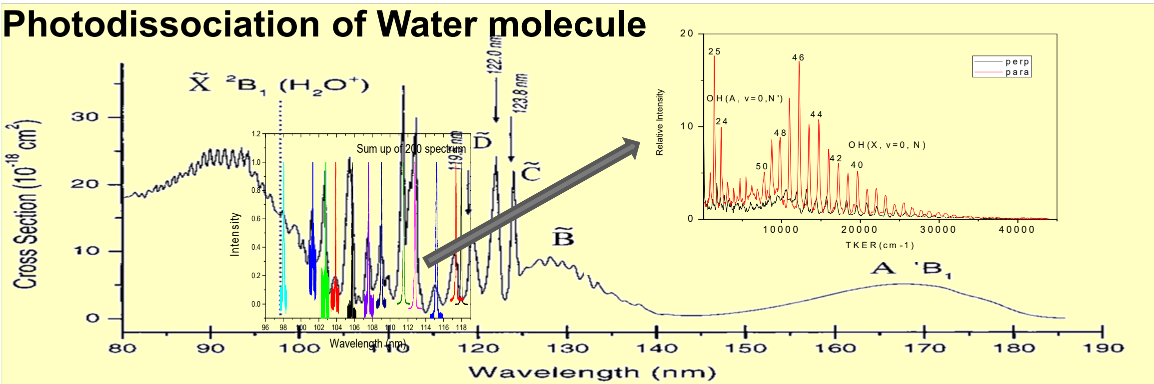
Courtesy: X.M. Yang

DCLS layout



Driving laser
Seed laser
Experimental hall
LINAC (300 MeV)
Undulator

User experiment on DCLS



Photodissociation dynamics of water molecule is done above 120nm before DCLS. Now it is extended to 98nm. Three body dissociation is found, which is very rare and interesting case.

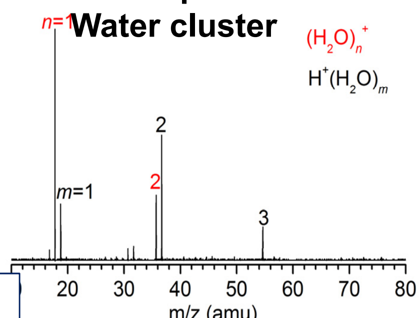
J. Chem. Phys. 148. 124301(2018)

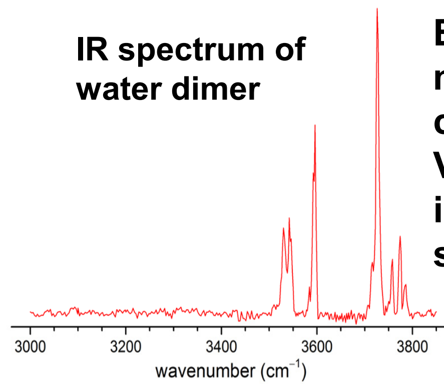
Editor's Pick

Rev. Sci. Intru. 89, 063113(2018)

Nature Comm., 10, 1250(2019)

IR spectrum of Neutral cluster





Courtesy: W.Q. Zhang

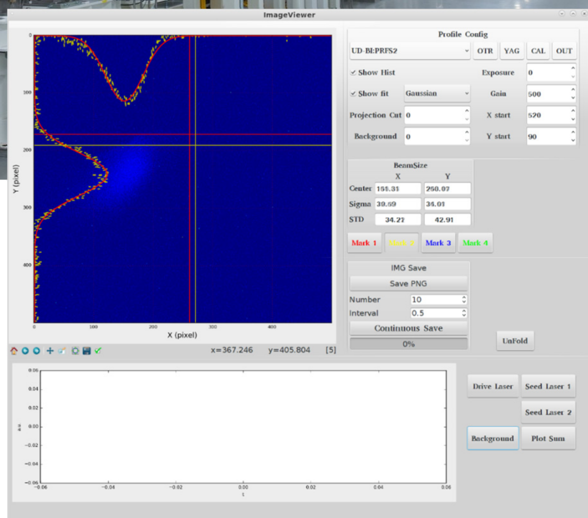
By VUV soft ionizing, we succeed to measure IR spectrum of neutral cluster, which is hard without strong VUV photon beam. It is very important to obtain cluster structure.

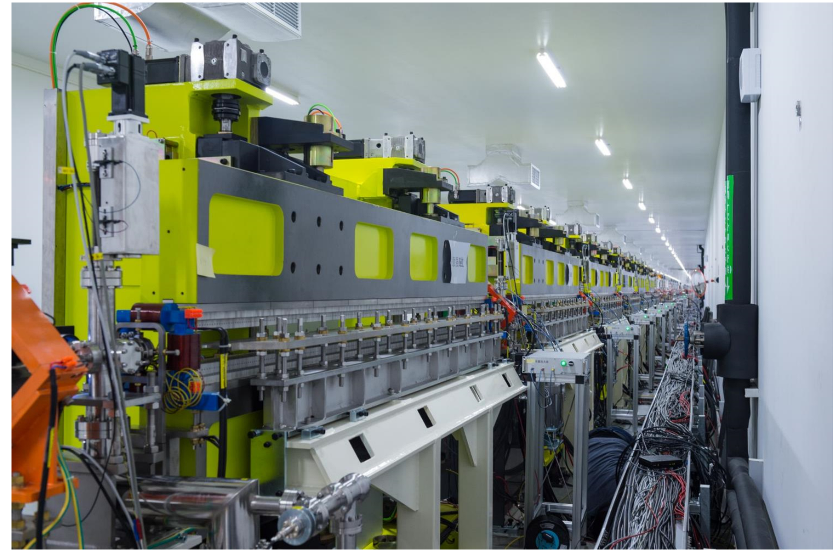
Next: high rep-rate FEL. R&D together with SHINE

SXFEL & SHINE

SHINE

X-ray FEL Test Facility：0.84GeV warm linac

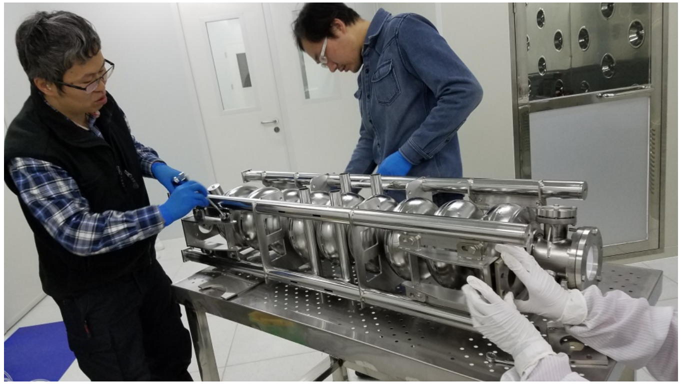


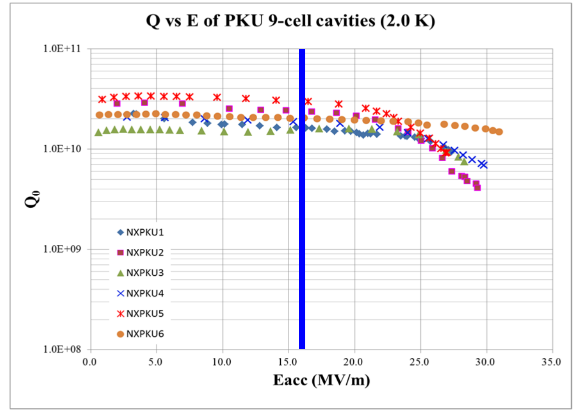


Cascaded HGHG FEL scheme lased at 8.8nm, April 30, 2019

SHINE

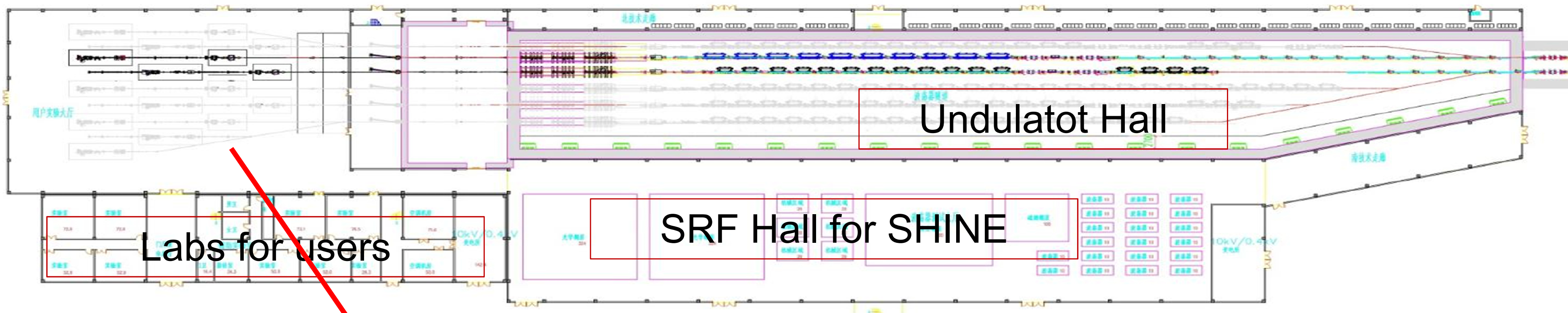
SRF R&D for future XFELs

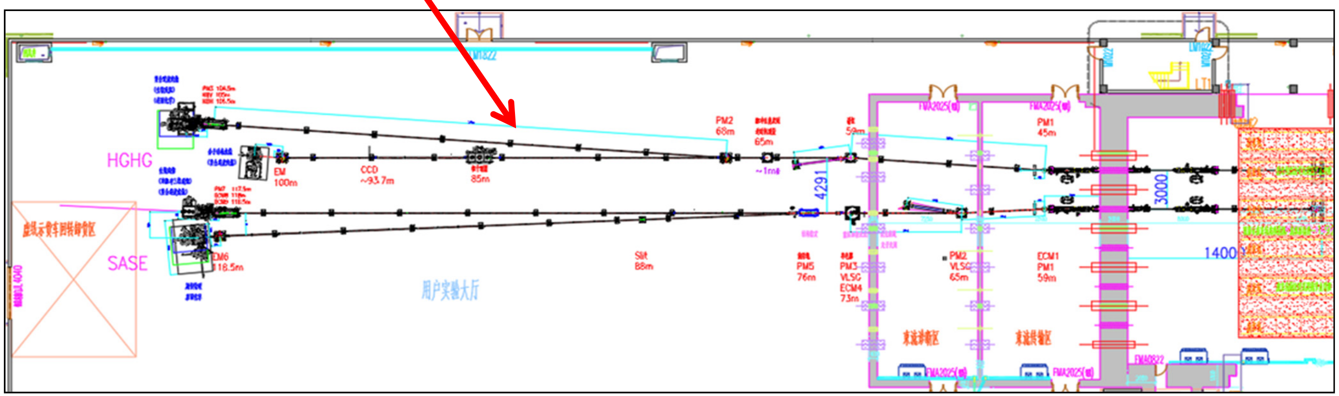




SHINE

SXFEL user facility

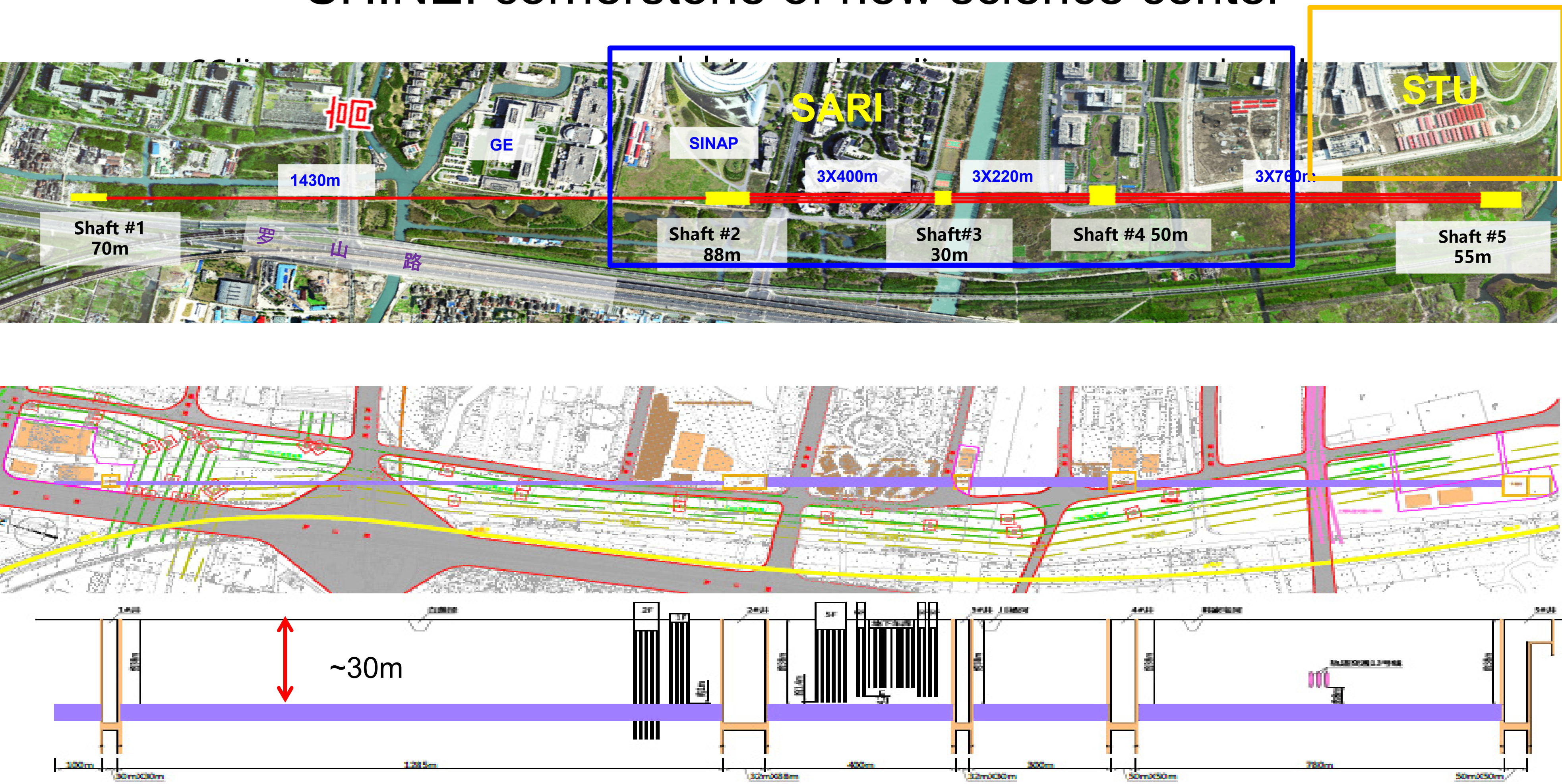




Experiment Hall

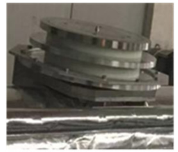
Seeded FEL line
SASE FEL line
Five end-stations total
Open to users at 2020

SHINE: cornerstone of new science center

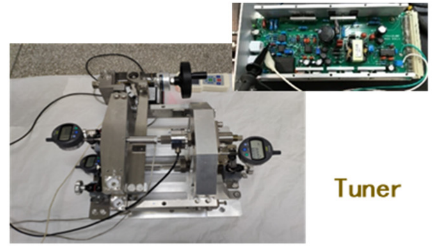


Prototypes for SHINE accelerator

Cavity support

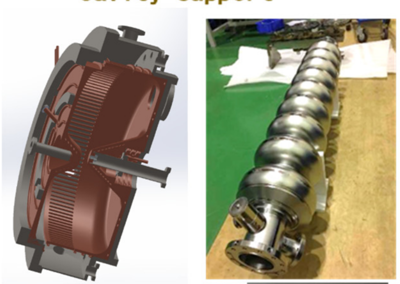


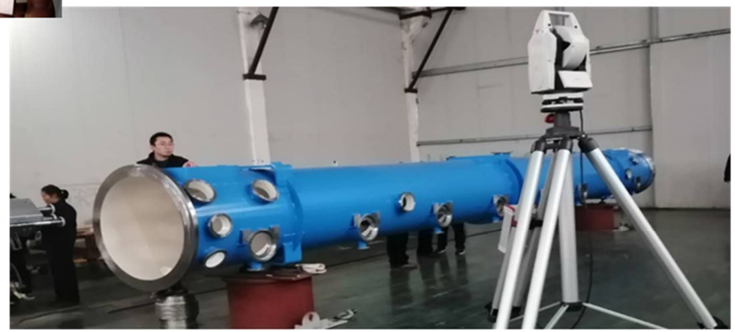
Cold mass



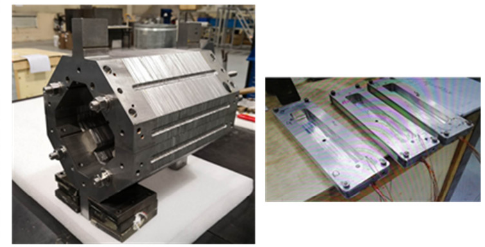
Tuner

BPM

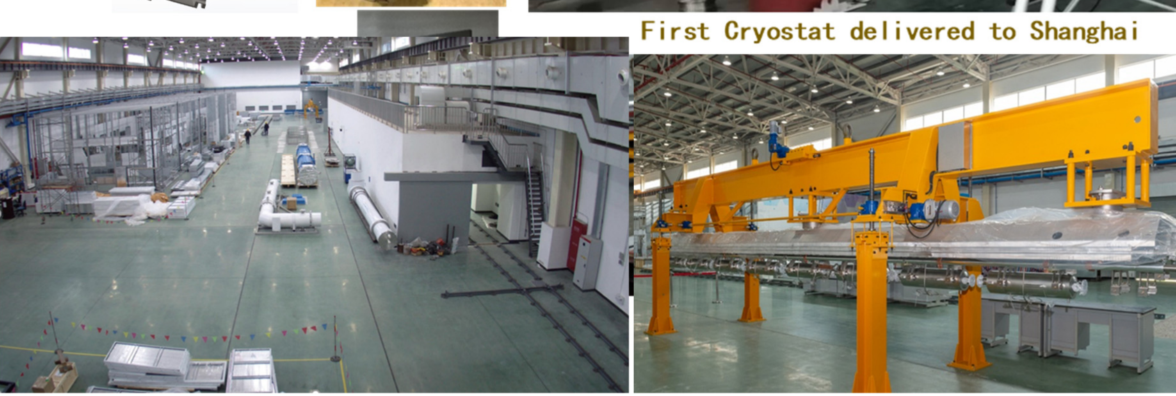




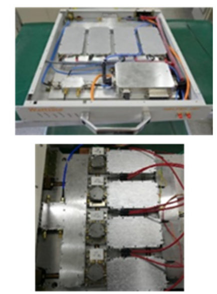
First Cryostat delivered to Shanghai



SCQ



Coupler

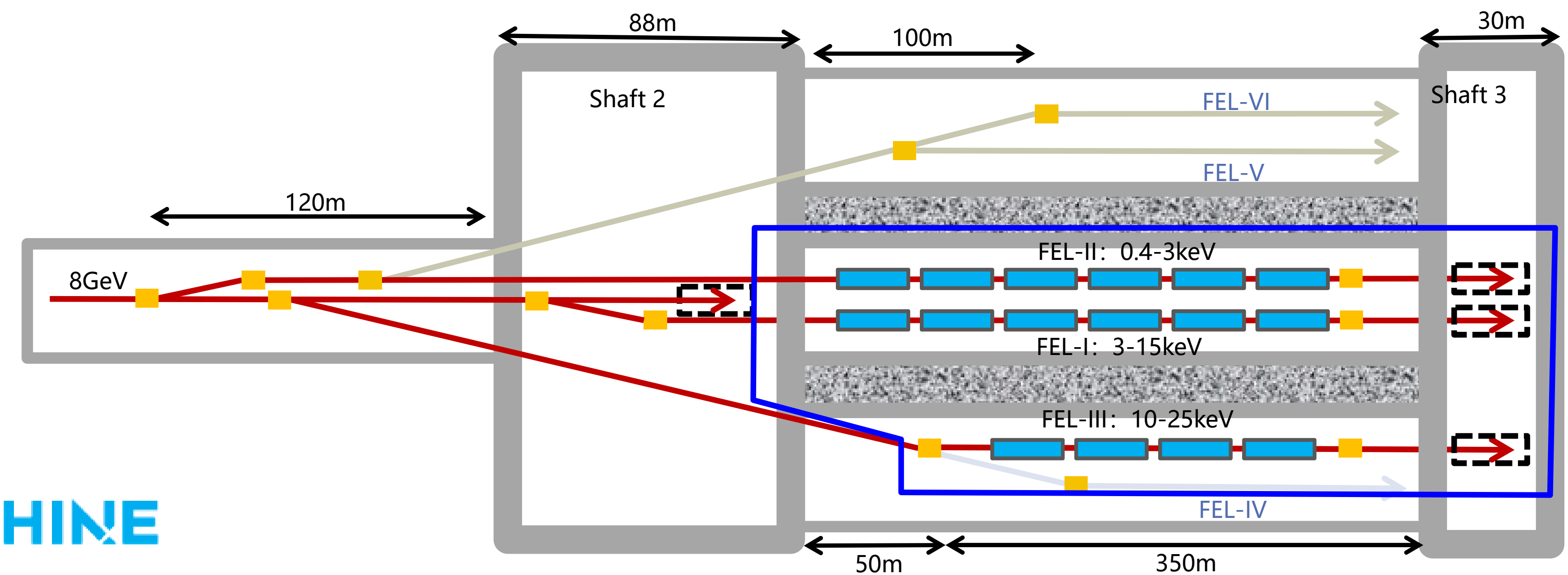


SSA

Undulator Layout and FEL Schemes

Three undulator beamlines to cover the photon energy range 0.4-25keV, external seeding and self-seeding schemes have been adopted for fully coherent FEL generation:

- FEL-I（3-15keV）：SASE、self-seeding
- FEL-II（0.4-3keV）：EEHG/HGHG、self-seeding
- FEL-III（10-25keV）：SASE、self-seeding



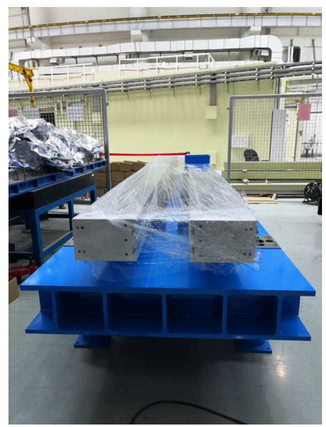
SHINE

SHINE undulators: SC/warm, HP/VP/Elliptical

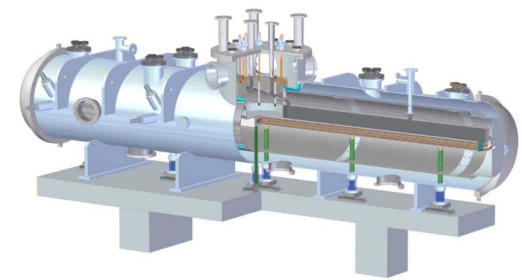
	FEL-I	FEL-II	
Type	Planar	Planar	Elliptical
Quantity	34	40	4
Period Length (mm)	26	68	68
Effective Length (m)	5	4	4
Minimum Gap (mm)	7	7	5
Maximum Peak Field (T)	1.0	1.5	1.5/1.5/1.06

Type	Planar
Quantity	40
Period Length (mm)	16
Effective Length (m)	4
Minimum Gap (mm)	5
Aperture (mm)	4
Maximum Peak Field (T)	1.58
Winding Material	NbTi/Cu
Cooling	LHe conduction, 4.2-4.5 K

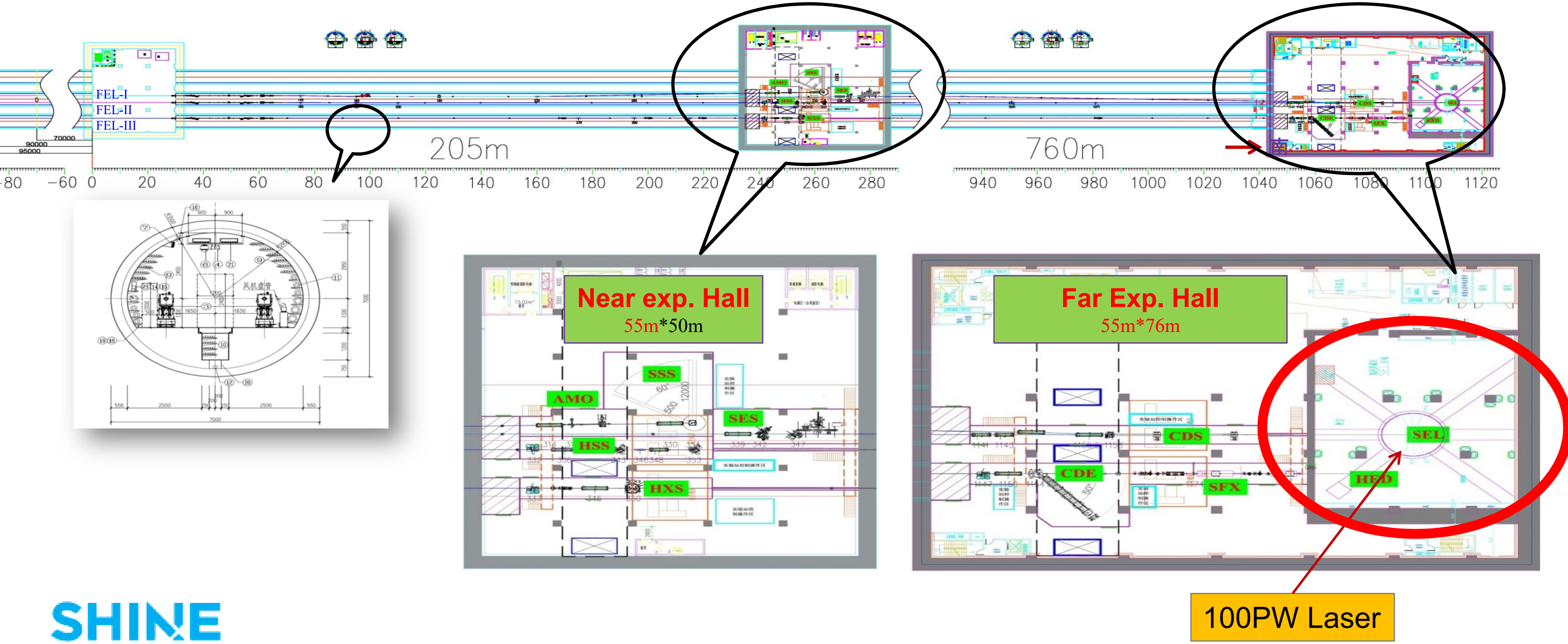
Permanent magnet undulators



Superconducting undulator



Photon beamlines /end-stations



SHINE

Summary

- Synchrotron light source in Asia/Oceania
  - 5 existing 3rd generation light source are running smoothly and adding more beamlines
  - 2 low emittance rings just kick off around IPAC19
  - A few new projects are on the horizon, as cornerstone for new research centers!
- Free Electron Laser in the region
  - FELs based on warm technology are mature. Multi-FELs operation are routine. More seeded FEL lines and other features.
  - Higher rep-rate XFELs ramp up in Asia.
  - New trend: synchrotron-XFEL combination from very beginning for greenfield projects, in Japan, China, Thailand and more…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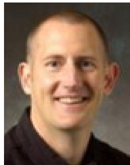

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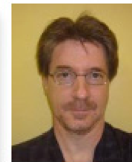

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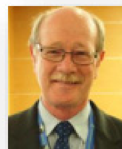

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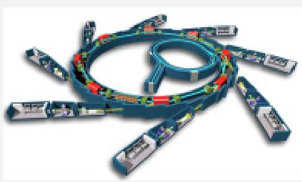
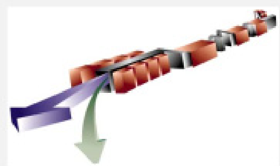
LEAPS

League of European Accelerator-based Photon Sources

A new consortium of excellence in Europe devising a transformative level of coordination and integration

European Synchrotron Radiation and FEL Facilities





are joining forces
to master
the challenges of the next decades

Courtesy:
T. Ishikawa

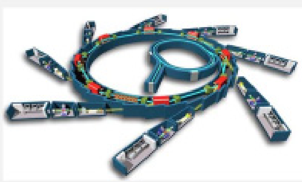
Asia/Oceania accelerator-based photon source community has been growing steadily and rapidly. Need for establishing Asia/Oceania consortium of photon sources like LEAPS for Europe.

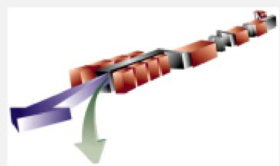
LEAPS

League of European Accelerator-based Photon Sources

A new consortium of excellence in Europe devising a transformative level of coordination and integration

European Synchrotron Radiation and FEL Facilities





are joining forces
to master
the challenges of the next decades

Courtesy:
T. Ishikawa

Thank you for your attention!