AFAD2018 (9th Asian Forum for Accelerators and Detectors)

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Status of Free Electron Lasers in SINAP

Zhentang Zhao, Dong Wang, Lixin Yin, Guoping Fang, Ming Gu, Yongbin Leng, Qiang Gu, Bo Liu

On behalf of the FEL team @ SINAP

Shanghai Institute of Applied Physics

Chinese Academy of Sciences

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Outline

- SDUV-FEL
- SXFEL
  - SXFEL-TF
  - SXFEL-UF
- SCLF
- Summary

High Gain FEL Facilities in China

SDUV-FEL:
65m, 180MeV, 250-350nm

Under commissioning

DCLS:
150m, 300MeV, 50-150nm

Under commissioning / Operation

SXFEL Facility:
293m, 840MeV, 9-40nm
532m, 1.5GeV, 2-10nm

High-gain FELs constructed in China

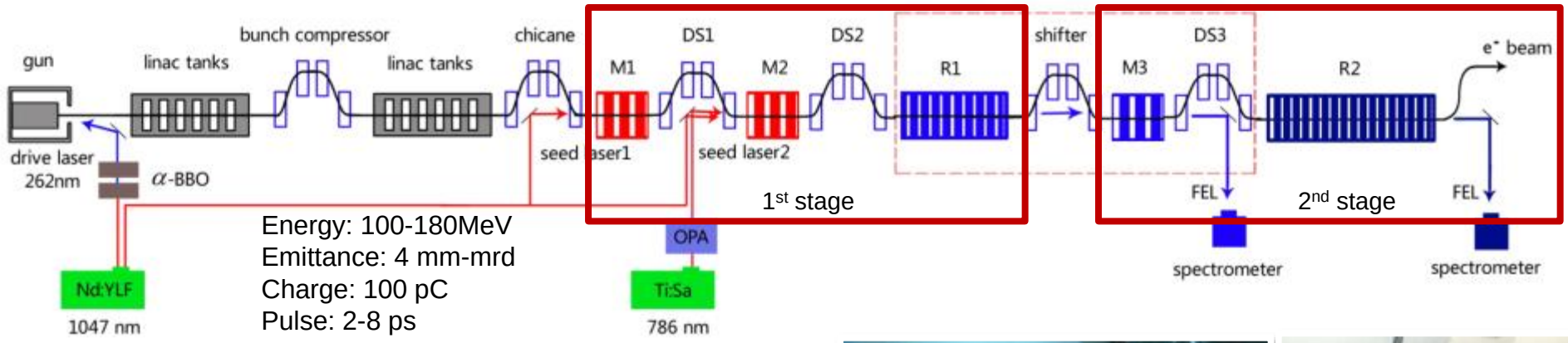
	SDUV-FEL	DCLS	SXFEL-TF	SXFEL-UF
	Test facility	User facility	Test	User
Status	Shutdown	Commissioning/ Operation	Commissioning	Construction
Wavelength	150-350nm	50-150nm	8.8nm	2.0nm
Length	65m	150m	293m	532m
Accelerator	S band	S band	S+C band	S+C band
Beam energy	100-200MeV	300MeV	0.84GeV	1.5GeV
FEL principle	HGHG, EEHG	HGHG	HGHG, EEHG	Cascaded HGHG SASE
Location	Shanghai	Dalian	Shanghai	Shanghai
First lasing	2009	2016	2017	**2019**

SDUV-FEL

Shanghai Deep-Ultraviolet Free Electron Laser

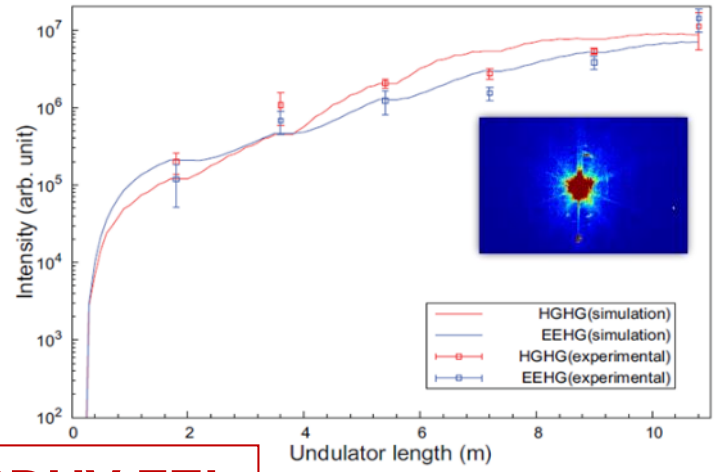
SDUV-FEL Building (SINAP Jiading Campus)

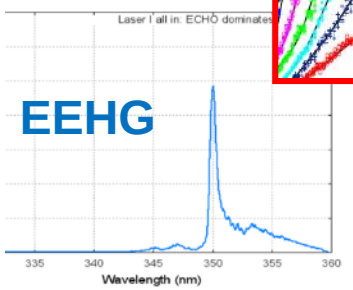
SDUV-FEL layout



Energy: 100-180MeV
Emittance: 4 mm-mrd
Charge: 100 pC
Pulse: 2-8 ps

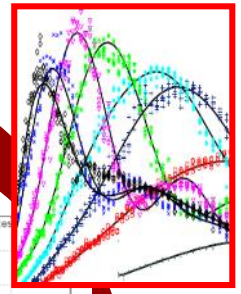
SDUV-FEL：seeded FEL Experiments





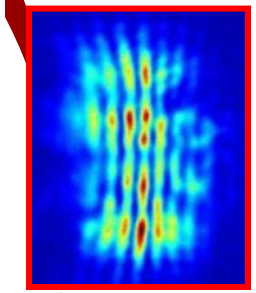
SDUV-FEL

A preparation for XFEL



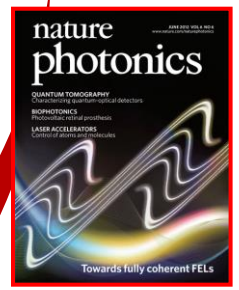
keV sliced energy spread measurement

Phys. Rev. ST-AB 14, 090701 (2011)



HGHG & cascaded HGHG

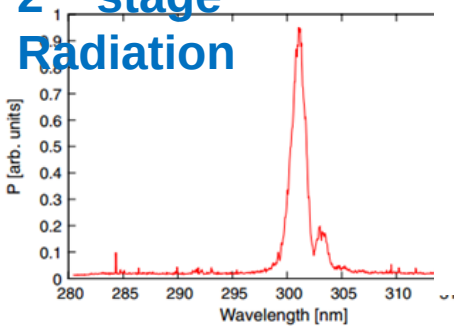
Phys. Rev. ST-AB 17, 020704 (2013)



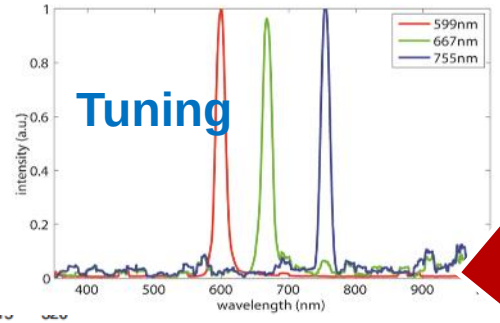
First lasing of Echo-FEL

Nature Photonics 06, 360 (2012)

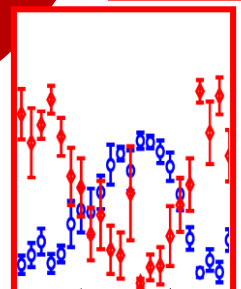
2nd stage Radiation



Tuning



DCLS、SXFEL、SCLF



Crossed-planar undulator demonstration

Phys. Rev. ST-AB 16, 020704 (2014)

SDUV-FEL: current status

- Many components of the SDUV-FEL has been moved to SXFEL
  - Klystron
  - Accelerating tubes
  - Undulators
  - Magnets / Power supplies
- A testbed for C-Band / X-Band accelerating structures
- Future development platform for high-repetition-rate high-brightness electron gun / injector (1MHz, 100pC)

SXFEL

Shanghai Soft X-ray Free Electron Laser

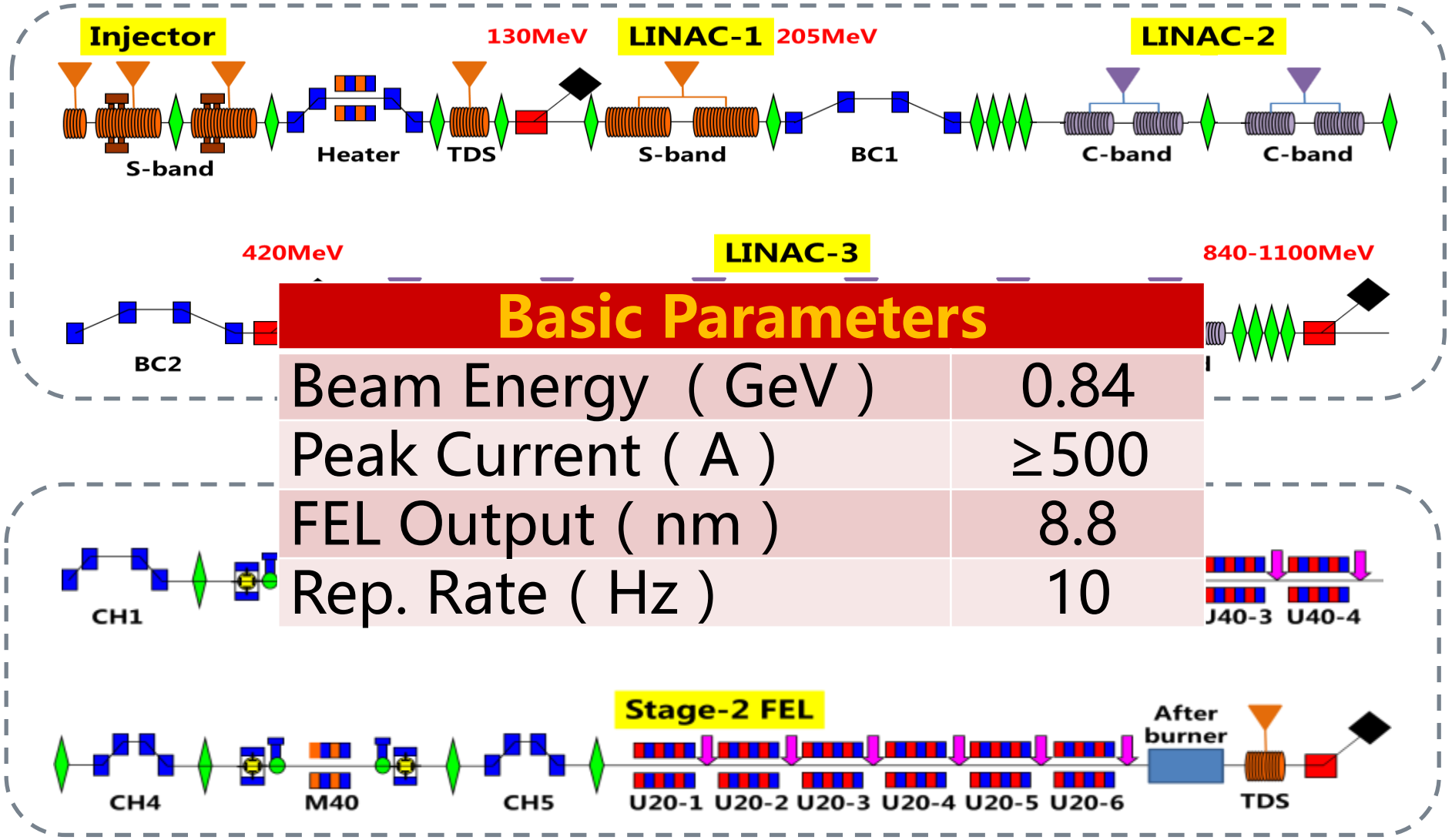
SXFEL at SINAP

SXFEL: Project Scope

‘phased’ project

- **1. SXFEL Test Facility**
  - Schedule: 2014.12 - 2017.12, under commissioning
  - Budget: $35M
  - Design goals: ~300m tunnel, 840 MeV linac, 8.8nm seeded FEL
  - Source: national funding agency
- **2. SXFEL User Facility (soft X-ray)**
  - Schedule: 2016.10 - 2019.03, under construction
  - Budget: ~$110M (80M for SINAP)
  - Design goals: add 250mx50m FEL and experiment halls,
    upgrade to1.5 GeV, 2 FEL lines, 5 end-stations
  - Source: local and national funding agencies

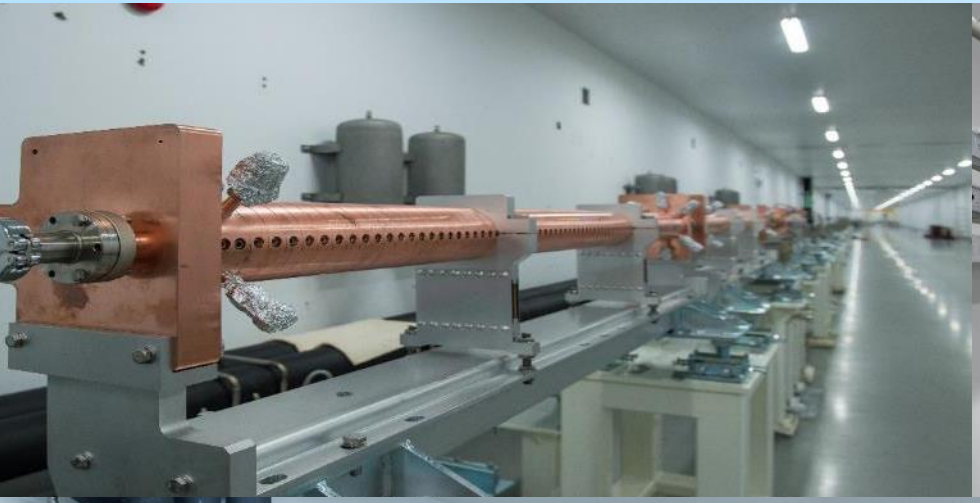
SXFEL-TF Layout

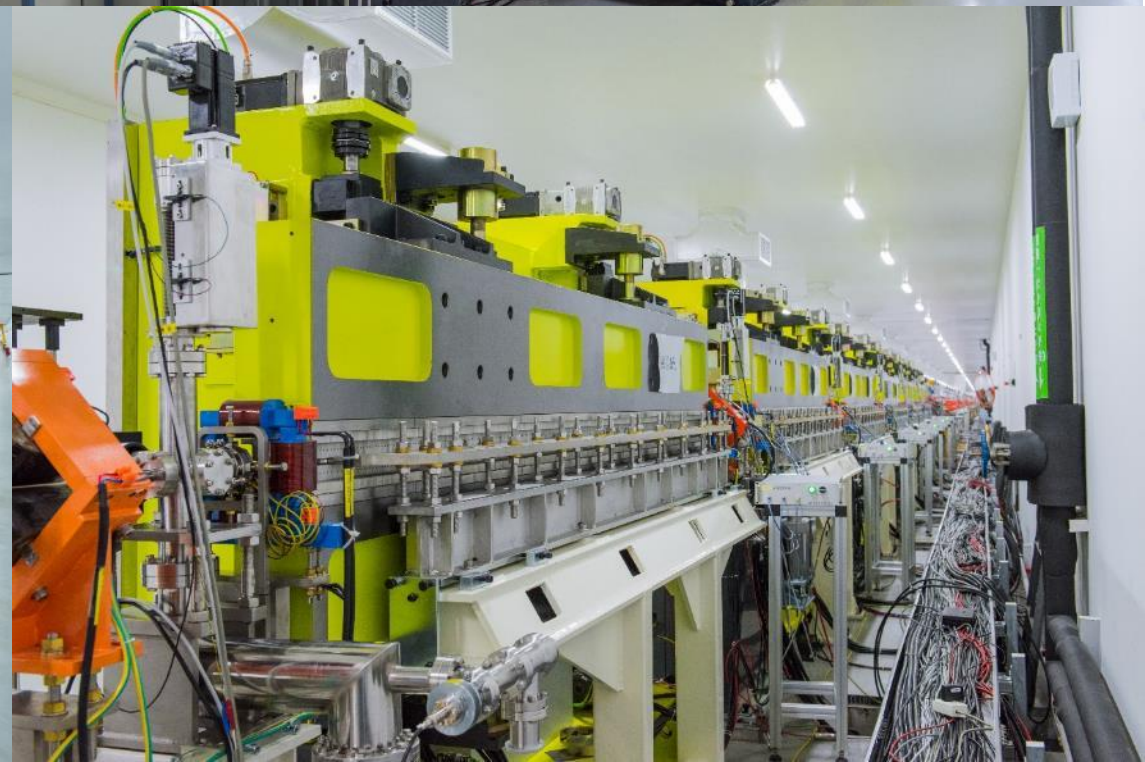


Basic Parameters	
Beam Energy （GeV）	0.84
Peak Current（A）	≥500
FEL Output（nm）	8.8
Rep. Rate（Hz）	10

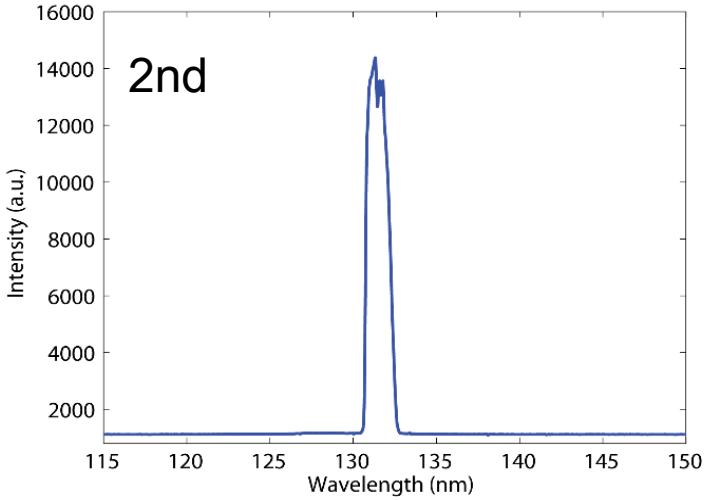
SXFEL Tunnel completion, 2016.4

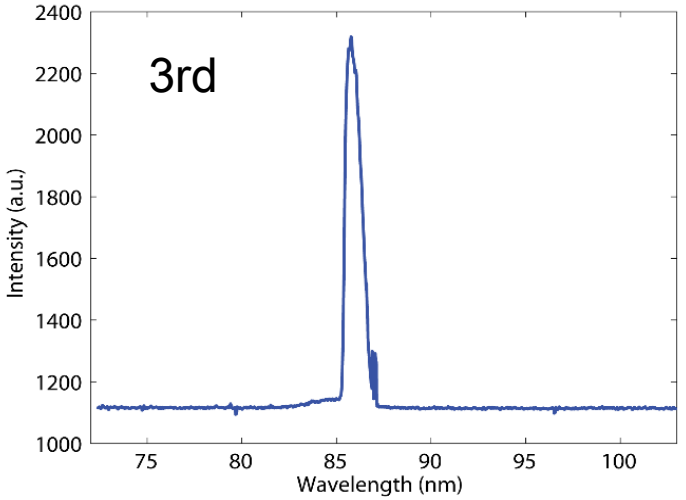
SXFEL installation

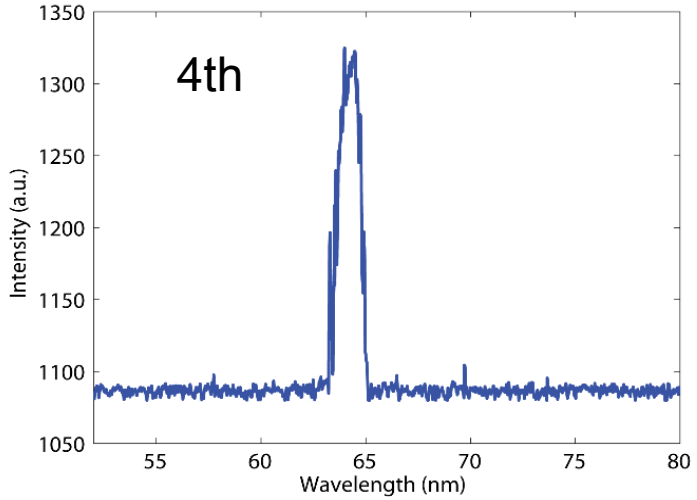




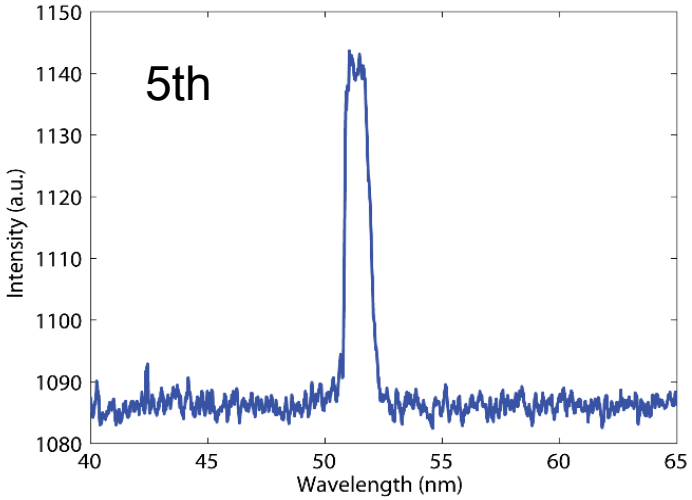
SXFEL commissioning

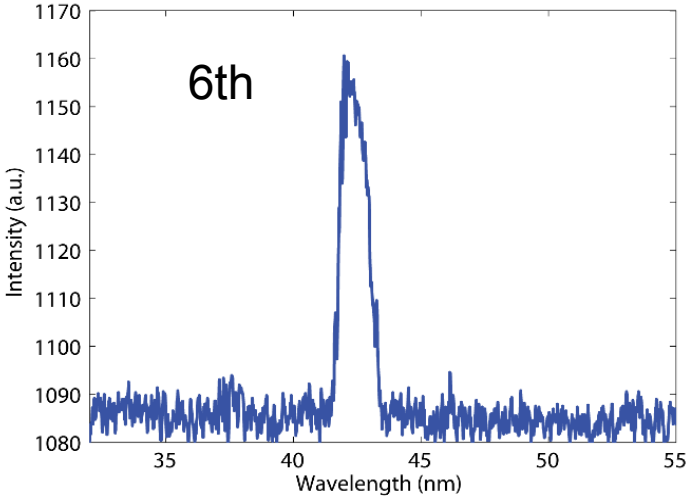




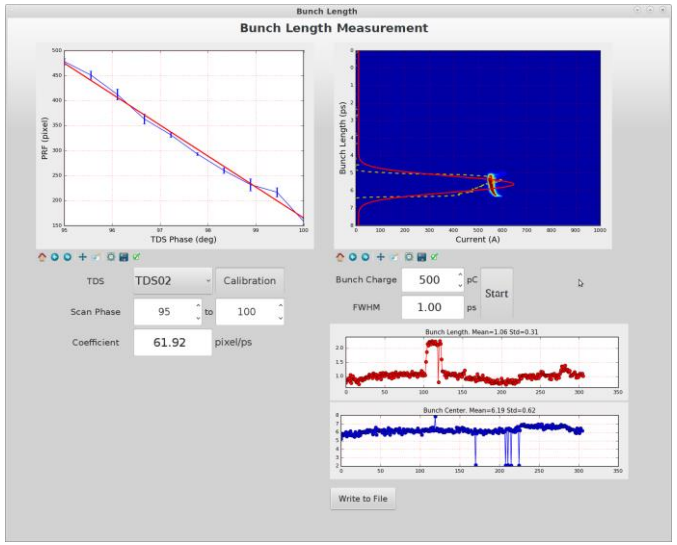


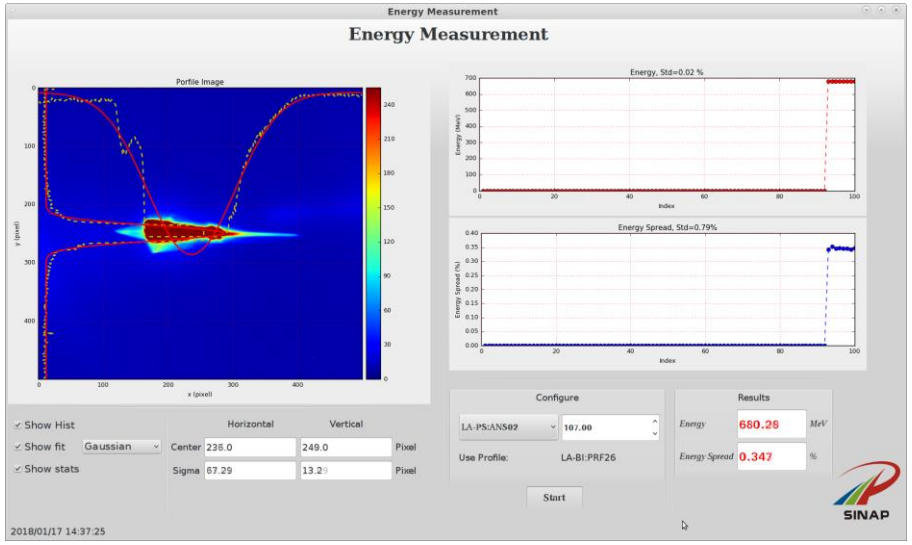
Spectrum of the first stage HGHG radiation (seed laser @~260 nm)
Measured with a McPherson 234/302 spectrometer



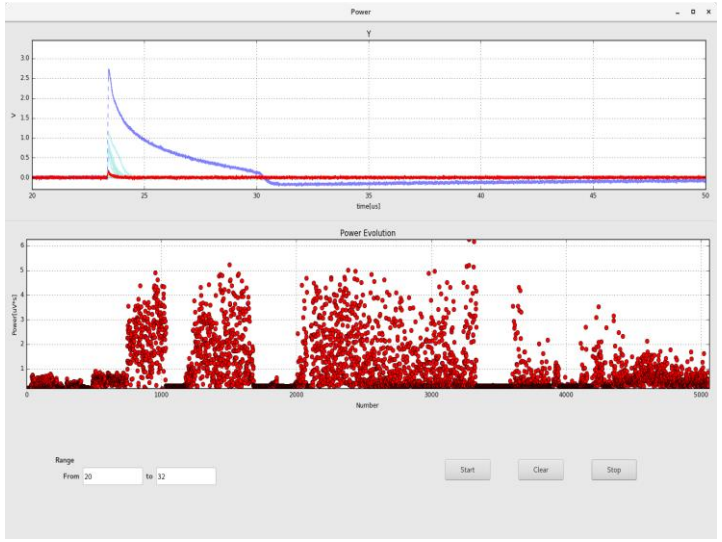


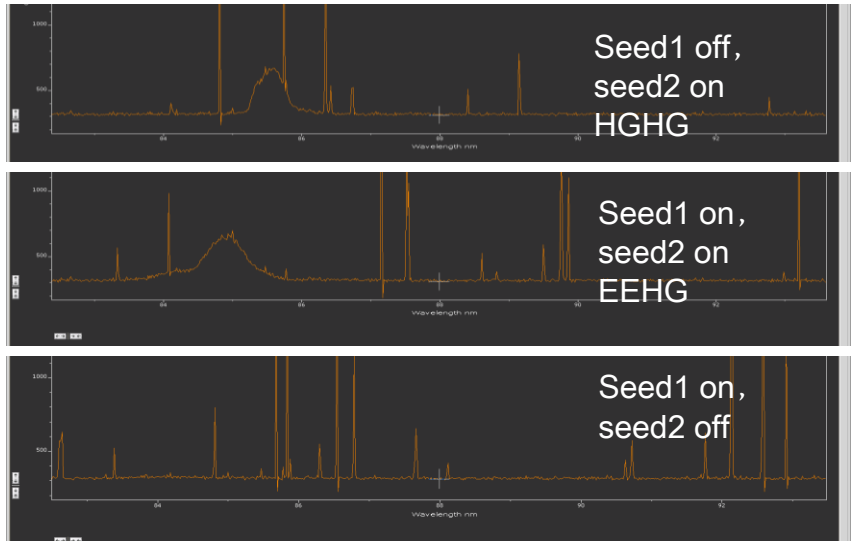
SXFEL commissioning: recent result





- Electron Energy: ~680MeV
- Emittance: 3.5/4.4
- Bunch Charge: 500pC
- Peak Current: >500A



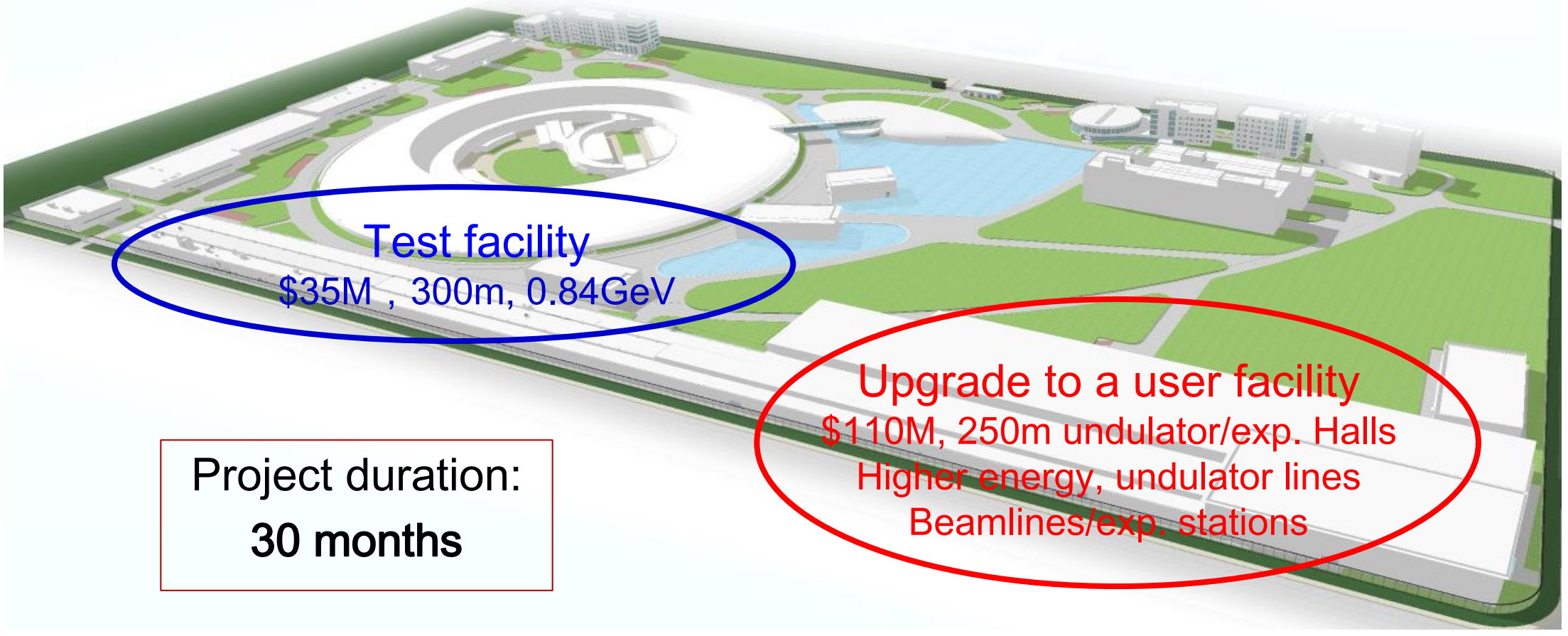


- Seed laser: 266nm / 266nm

- Wavelength shift has been observed under EEHG condition (@~88nm)
- Pulse energy is estimated to be >100μJ (measured with PD AXUV100G)

SXFEL User Facility: 2016-2019

- New funding for upgrade to user facility with $110M.
- Build undulator/experimental halls and increase beam energy.
- Jointly with Shanghai Tech Uni.(mainly responsible for user stations)

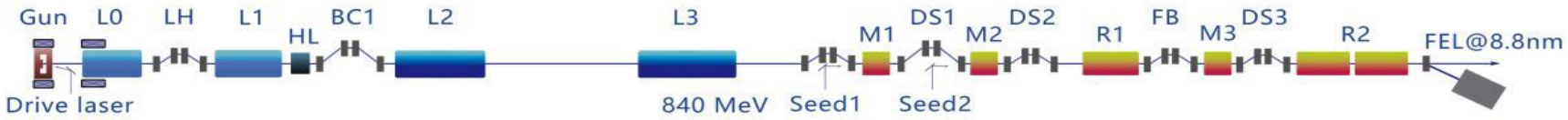


Project duration:

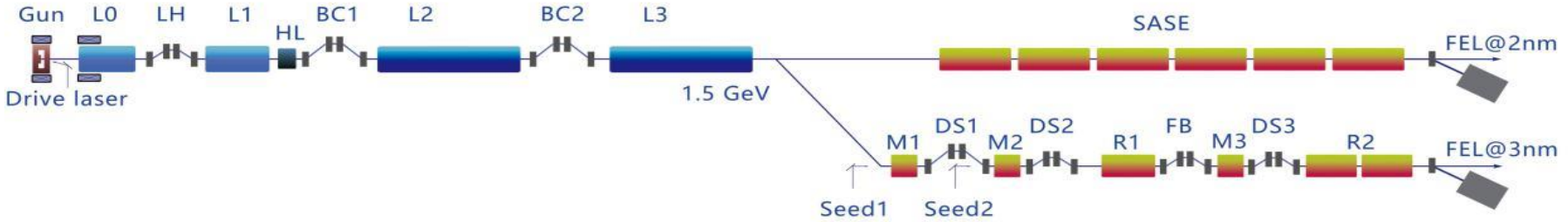
30 months

Parameters of SXFEL-TF & SXFEL-UF

SXFEL-TF

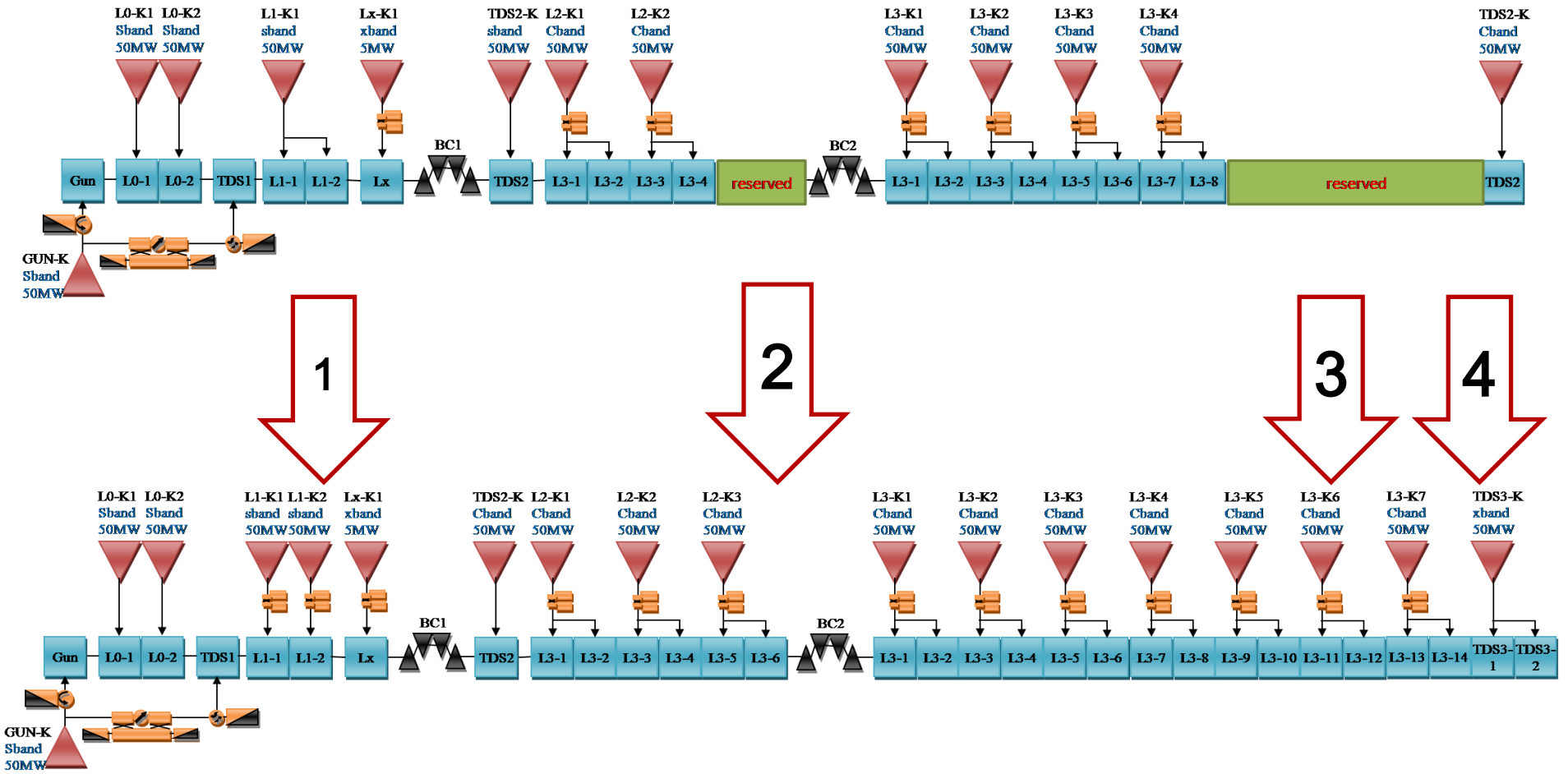


SXFEL-UF



Main Parameters	SXFEL-TF	SXFEL-UF
Beam Energy (GeV)	0.84	**1.5**
Norm. Emit. (mm·mrad , rms)	≤2	≤1.5
Bunch Charge (nC)	0.5	0.5
Peak Current (A)	≥500	**≥700**
Rep. Rate (Hz)	10	50
FEL Output (nm)	~8.8	**~2-3**
FEL Output Peak Power (MW)	≥100	≥100

SXFEL-UF: Linac energy upgrade



Adding:

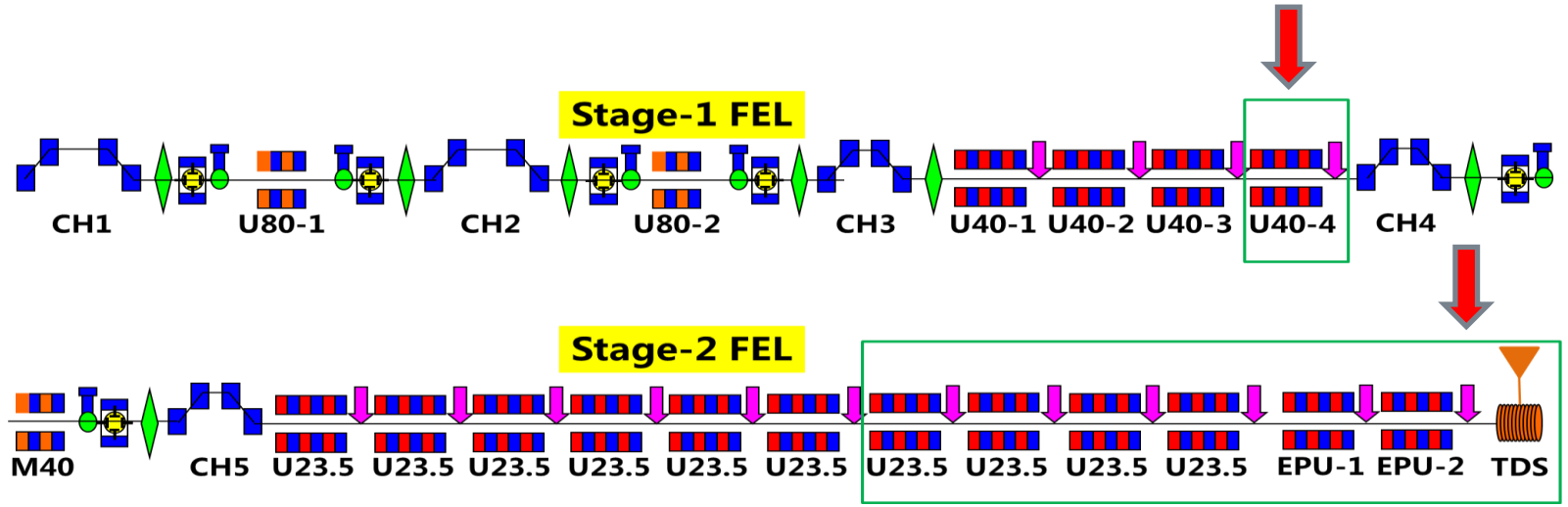
1) 1 S-band klystron and 2 SLEDs

2) 1 C-band RF unit
3) 3 C-band RF units

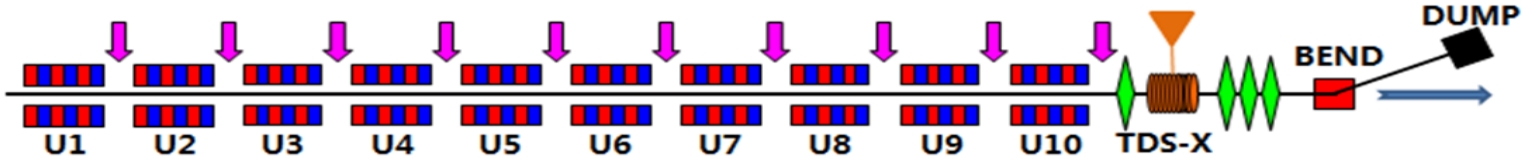
4) 1 X-band deflecting structure

SXFEL-UF: FEL lines

- **FEL1: Seeded FEL line**: add 7 undulator units

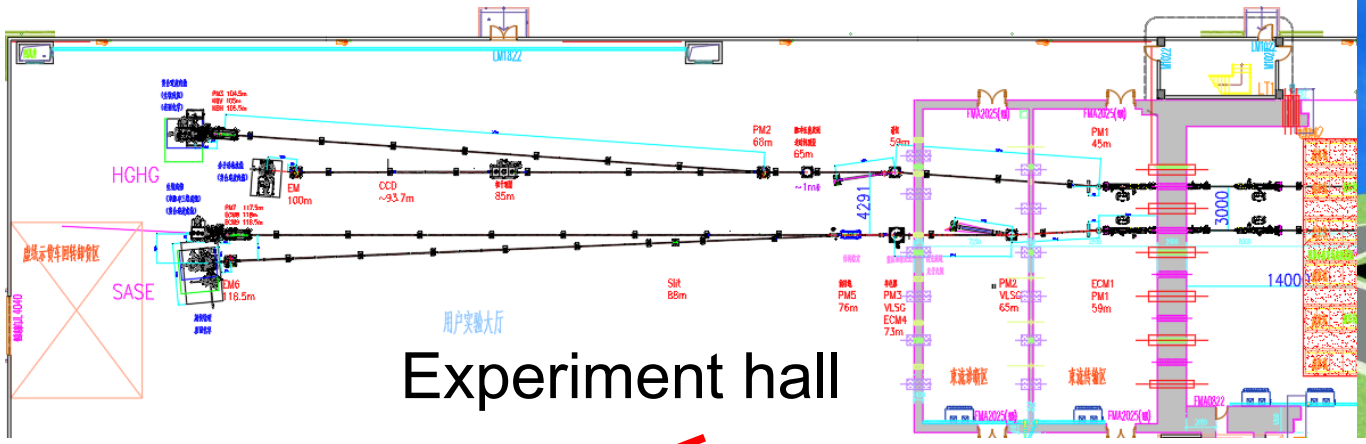


- **FEL2: SASE FEL line**: build 10 in-vacuum undulator sections

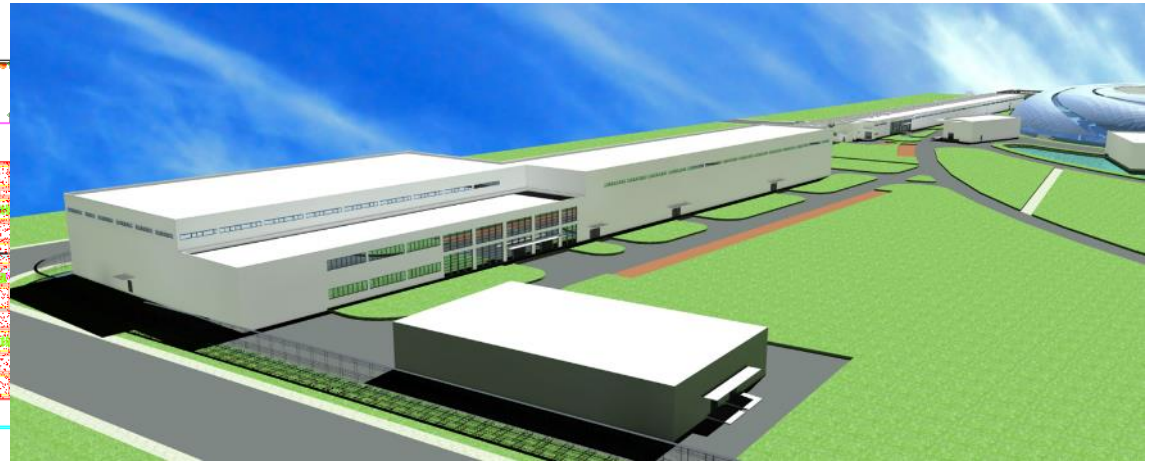


SXFEL-UF: End-Stations

5 Experimental Stations: Coherent Diffraction Imaging, Atom Molecules Optics, Ultrafast Physics, Surface Chemistry, Photon-Electron Spectroscopy



Experiment hall



SXFEL-UF Building

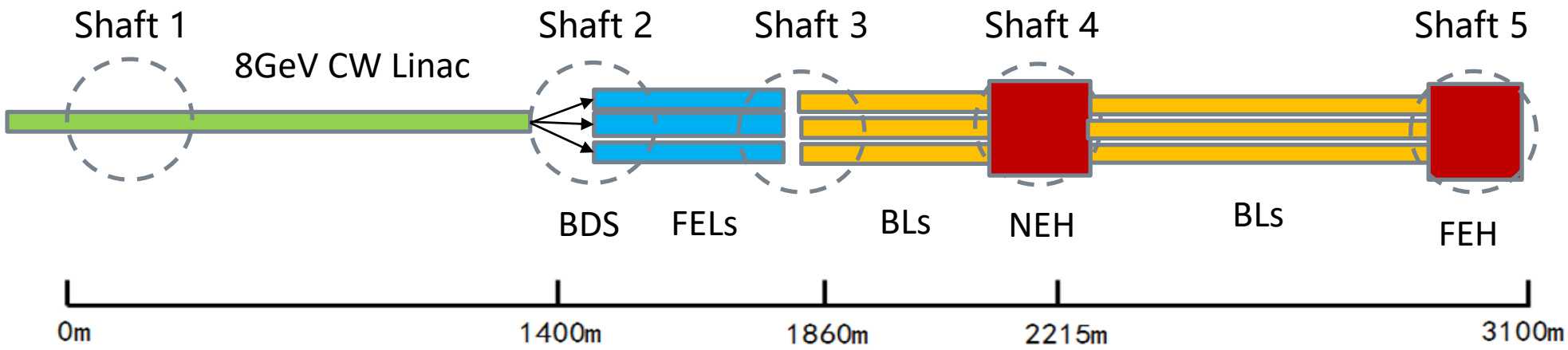
SCLF

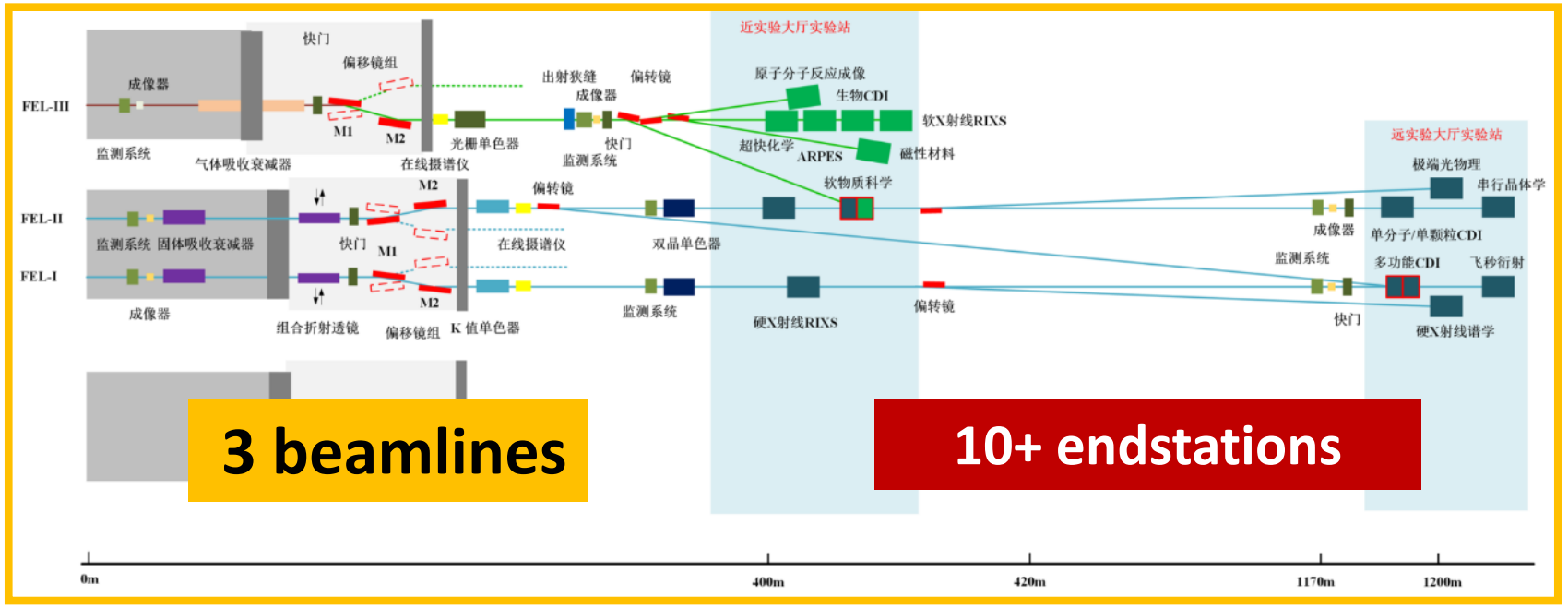
Shanghai Coherent Light Facility

Shanghai Coherent Light Facility (SCLF)

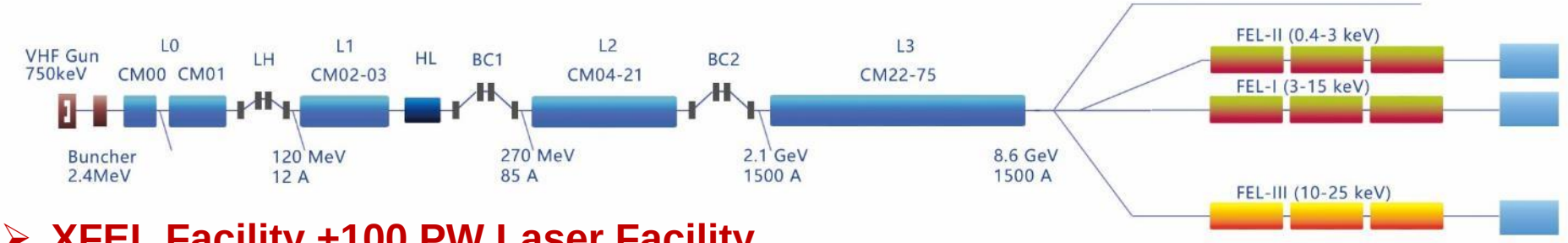
- SCLF is a newly proposed MHz high rep-rate XFEL, based on an 8 GeV CW SRF linac.
- SCLF is led by ShanghaiTech University, jointly with SINAP and SIOM. SINAP takes charge of the accelerator part and the FEL part.
- This facility will be built in a 3.1 km long tunnel (29 m underground) at Zhang-Jiang High Tech Park, across the SSRF campus in Shanghai.
- This XFEL facility includes 3 undulator lines and 10 experimental stations in phase one, it can provide the XFEL radiation in the photon energy range of 0.4 - 25 keV.
- The project proposal was approved by the central government in April 2017, and the feasibility study report has been approved in November 2017.

Conceptual Layout of SCLF

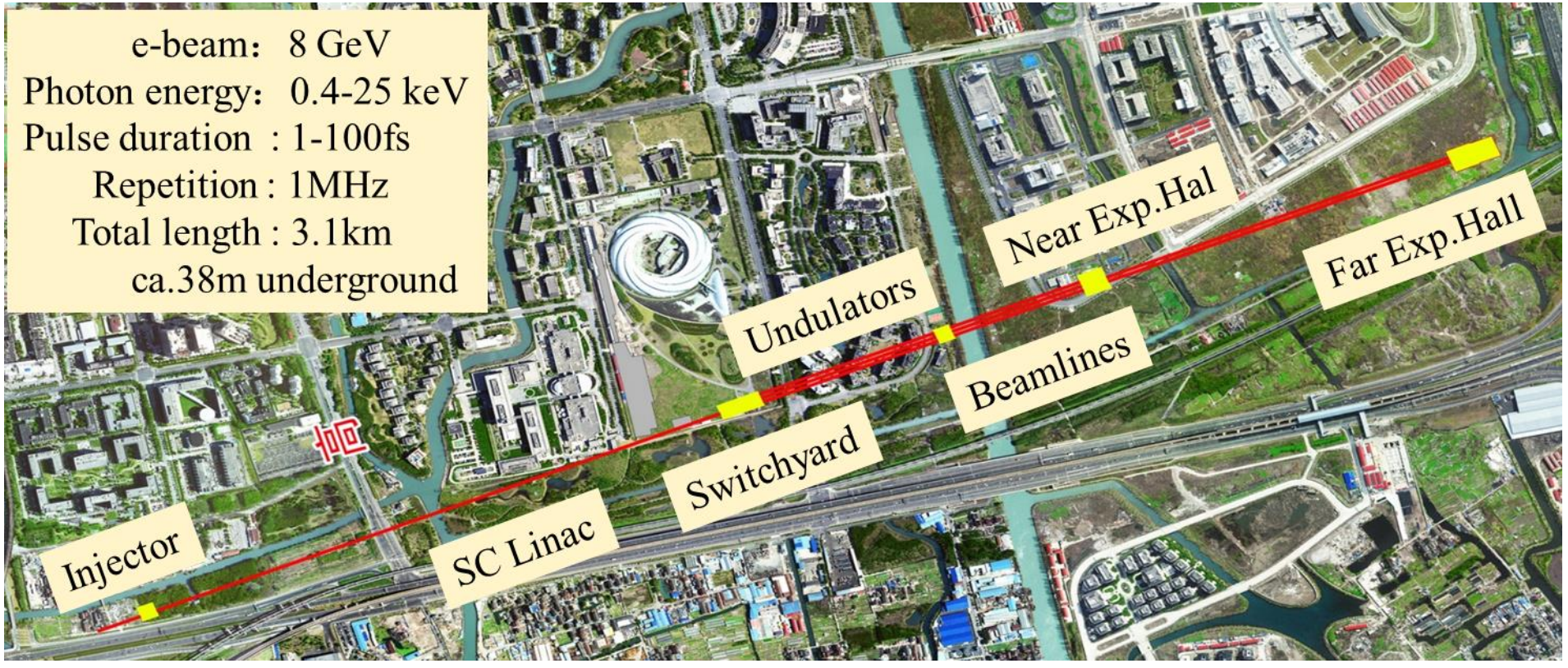




SCLF: A high-rep rate XFEL based on SCRF

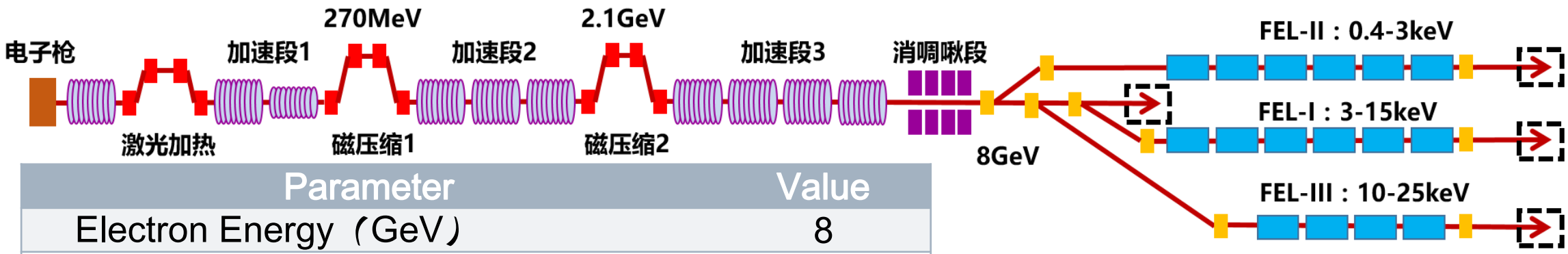


- **XFEL Facility +100 PW Laser Facility**




N
Shanghai Hard X-ray FEL
Injector
Linac
SINAP
Switchyard
S
STU
Far Hall
SARI
Near Hall
Beam Dump

Main Parameters of the SCLF



Parameter	Value
Electron Energy（GeV）	8
Slice energy spread（rms）	≤0.01%
Slice emittance（mm·mrad，rms）	≤0.4
Bunch charge（pC）	20-200
Peak Current（A）	1500 - 3000
Rep-rate（kHz）	1000

	Design Goal	Initial Stage
Photon Energy	3-15keV	5-13keV
Photon number /pusle	$>10^{10}$@12.4keV	$>10^{9}$@5keV
Photon Energy	0.4-3keV	1-2keV
Photon number /pusle	$>10^{12}$@1.24keV	$>10^{10}$@1.24keV
Photon Energy	10-25keV	10-15keV
Photon number /pusle	$>10^{10}$@15keV	$>10^{8}$@15keV

Summary

- Many interesting experiments had been done at SDUV-FEL, the first high-gain free-electron laser in China. We have got a lot of valuable results and gained rich experiences.
- A soft X-ray FEL facility based on 840 MeV linac is under commissioning, some preliminary results have been obtained. Meanwhile, it will be upgraded to a user facility by adding more accelerating units, building a new undulator line, two beamlines and five end-stations. The civil construction goes smoothly, and the user facility is aiming at serving users in 2019.
- An CW SRF linac based hard X-ray FEL facility is planned to be developed in Shanghai. The project proposal was approved by central government in April 2017 and the feasibility study report approved in November 2017. The detailed design report and budget have been reviewed by the local government recently.


Thanks!!!