Status of the SXFEL and DCLS

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on behalf of the SXFEL & DCLS project team

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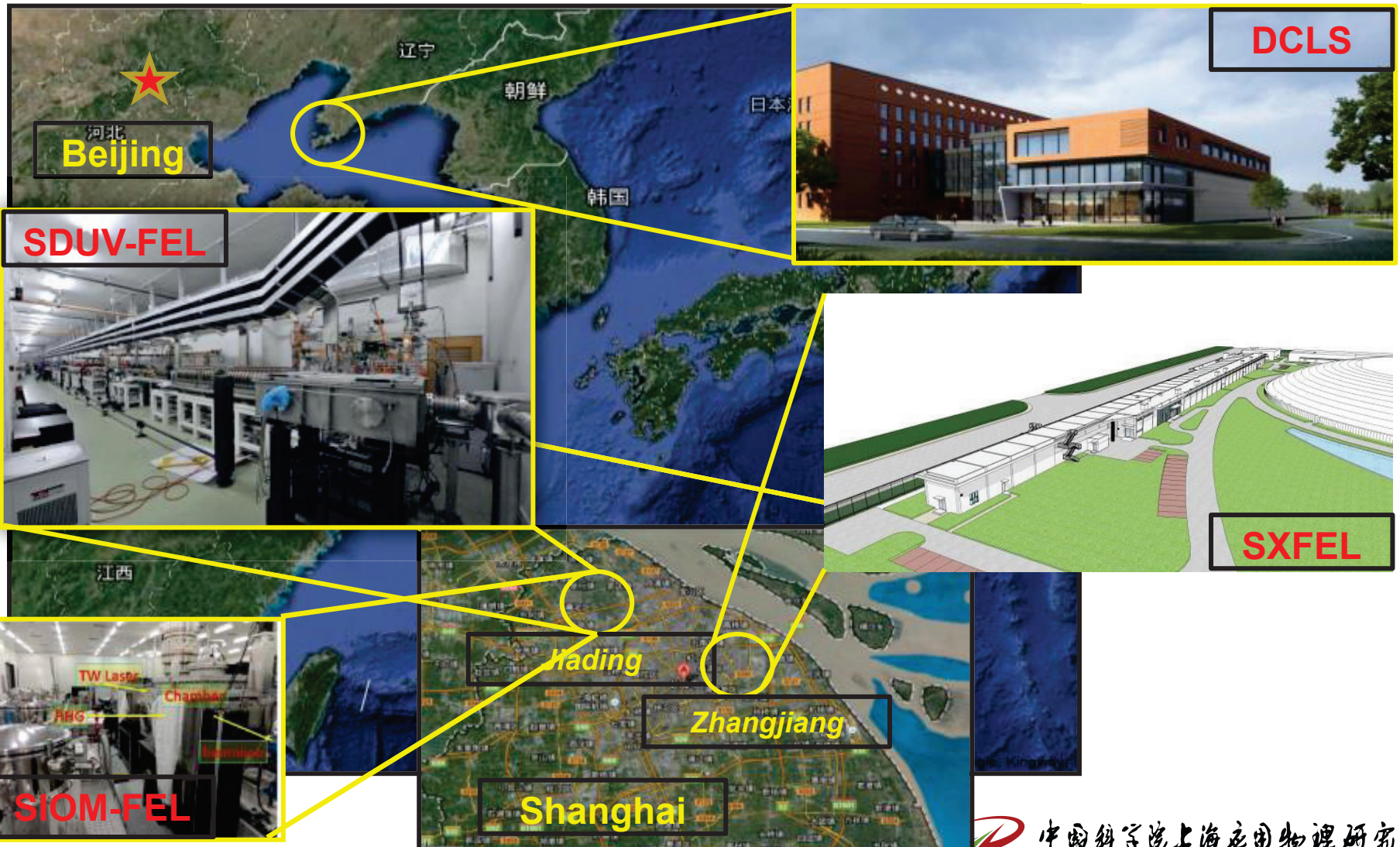
Outline

- Introduction
- Shanghai X-ray Free-Electron Laser test facility (SXFEL)
- Dalian Coherent Light Source (DCLS)
- Key component R&Ds
- Status of the projects
- Summary & Outlook


Free Electron Lasers in China
Low gain FEL
High gain FEL
CHINA
IR FEL
IR FEL
IR FEL@USTC
Dalian
EUV FEL
(DCLS)
Shanghai
X-ray FEL
Test Facility
(SXFEL)
蒙古
朝鲜
韩国
日本
中国
北京
上海
成都
重庆
武汉
新德里
New Delhi
孟加拉国
缅甸
老挝
泰国
河内
Ha Noi
加尔各答
Kolkata
海得拉巴
Hyderabad
孟买
Mumbai
浦那
Pune
艾哈迈达巴德
Ahmedabad
斋浦尔
Jaipur
勒克瑙
Lucknow
拉合尔
Lahore
伊斯兰堡
Islamabad
阿拉木图
Алматы
吉尔吉斯斯坦
乌兰巴托
Улаанбаатар
新西伯利亚
Новосибирск
札幌
青森
秋田
盛岡
日本海
新潟
仙台
金沢
長野
福島
東京
名古屋
静岡
大阪
広島
山口
福岡
松山
長崎
熊本
鹿児島
东海
南海
那覇
马尼拉
Maynila

High-gain FELs constructed in China



High-gain FELs constructed in China

	SDUV-FEL	DCLS	SXFEL	HXFEL
	Test facility	User facility	Test / User	User
Status	Operating	Construction	Construction	Proposal
Wavelength	150-350 nm	50-150 nm	3-9 nm	0.15 nm
Length	65 m	150 m	~300 m	~600 m
Accelerator	S band	S band	S+C band	S+C/X band
Beam energy	100-200 MeV	300 MeV	0.84-1.4 GeV	6.0 GeV
FEL principle	HGHG,EEHG	HGHG	HGHG,EEHG	SASE
Location	Shanghai	Dalian	Shanghai	Shanghai
First lasing	2009.09	2017	2017	

SXFEL in brief : X-ray FEL Test Facility

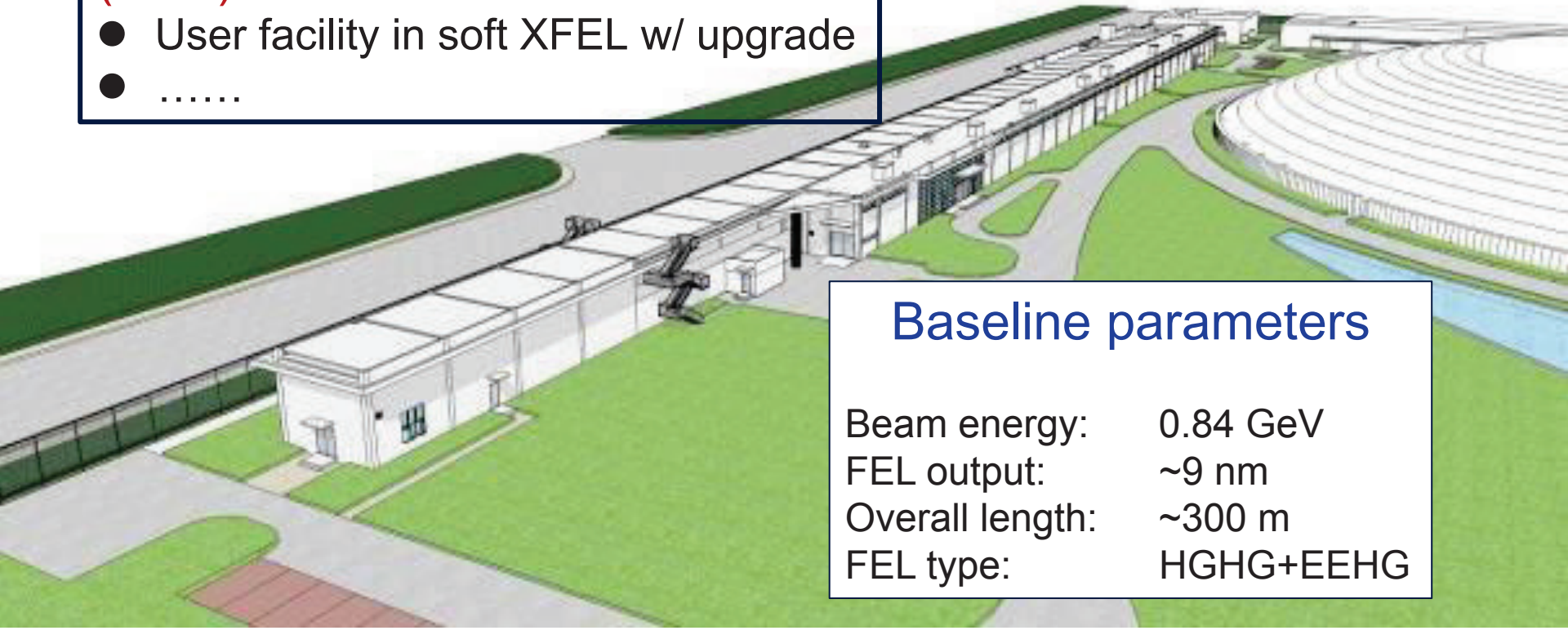
(Initial) Main goal of the project:

A 'R&D prototype' of hard X-ray FEL

- Explore key FEL schemes and technologies
- Build up XFEL teams and train young people

(Now) add more context:

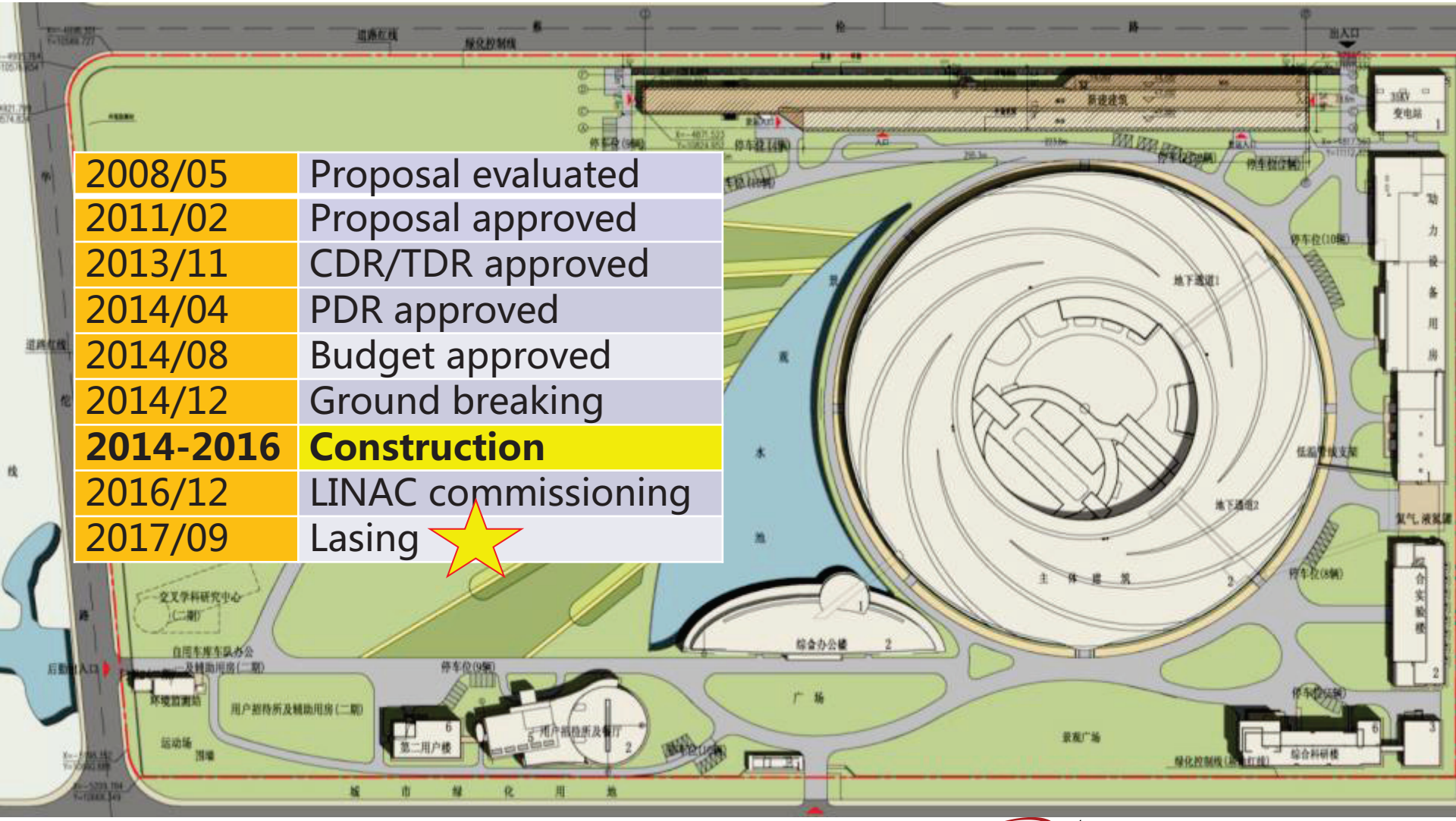
- User facility in soft XFEL w/ upgrade
- ……



Baseline parameters

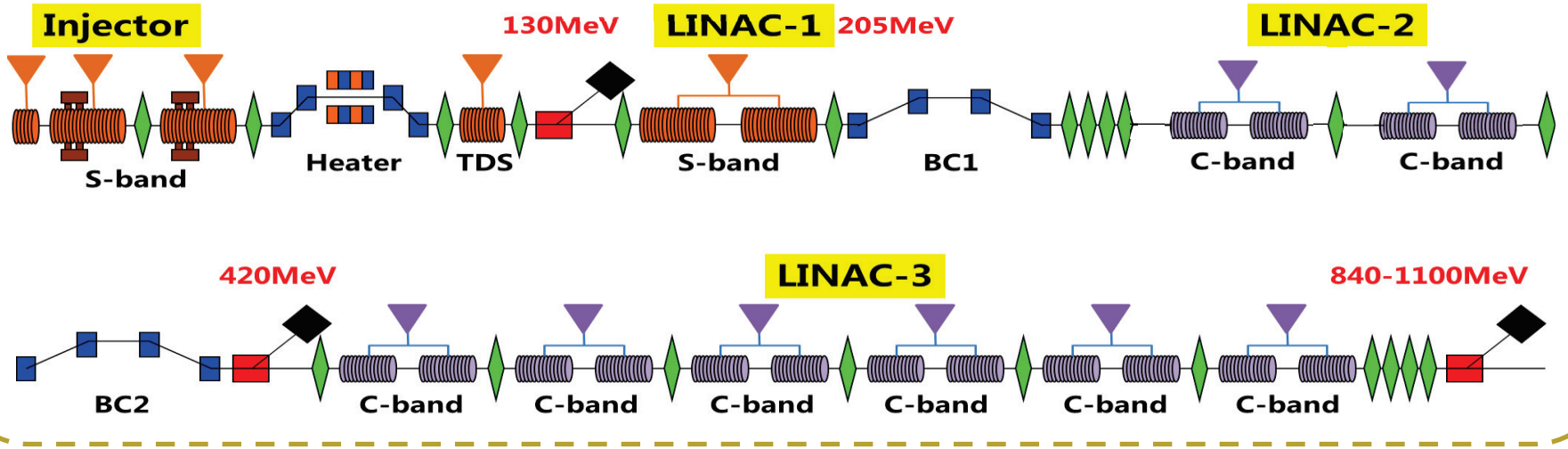
Beam energy:	0.84 GeV
FEL output:	~9 nm
Overall length:	~300 m
FEL type:	HGHG+EEHG

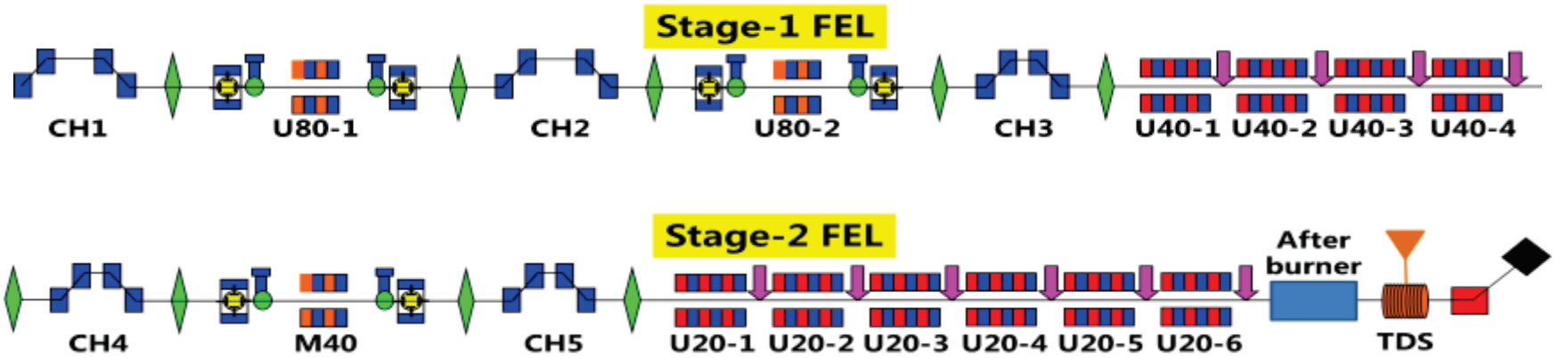
SXFEL in SINAP Zhangjiang campus



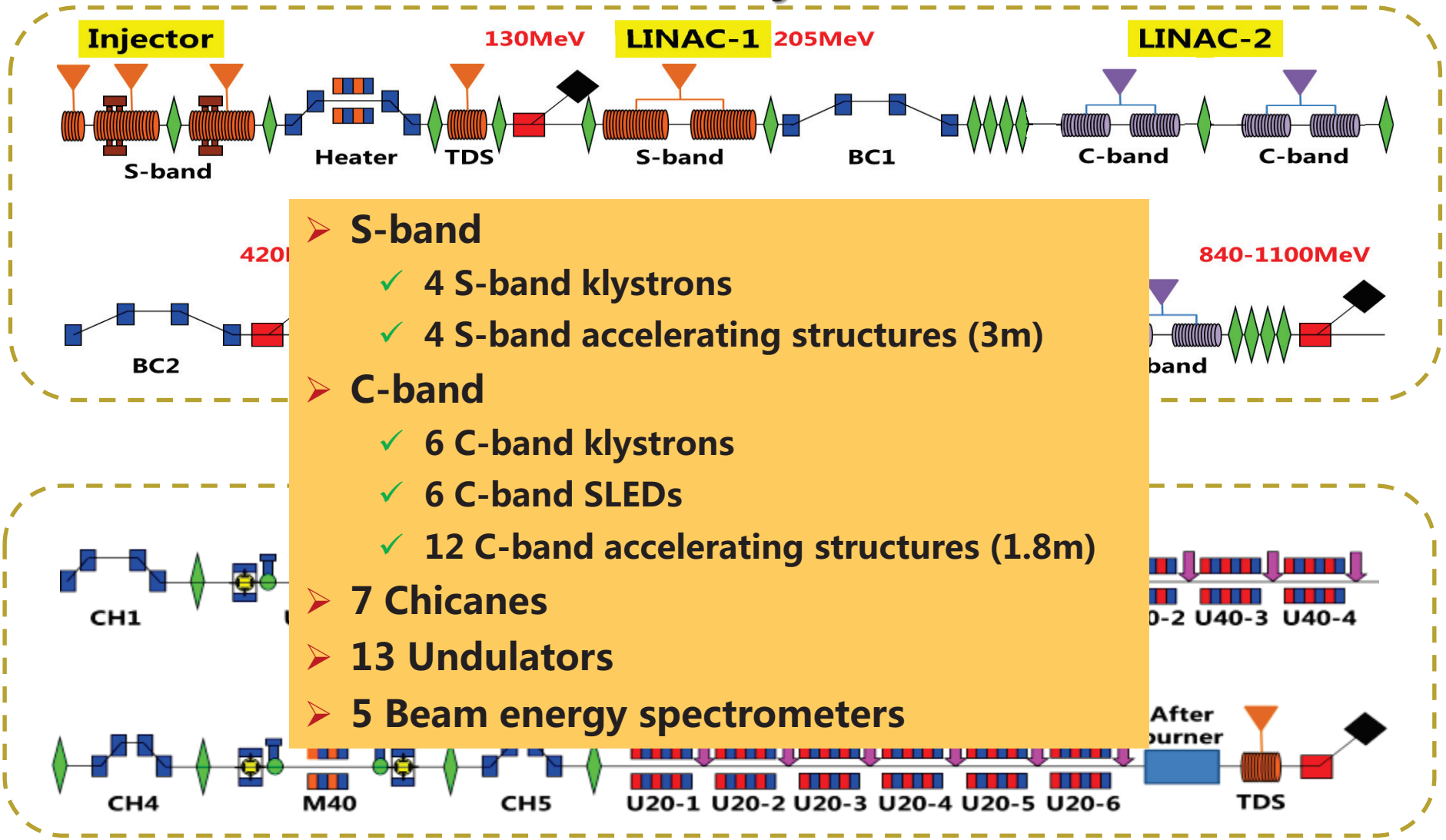
2008/05	Proposal evaluated
2011/02	Proposal approved
2013/11	CDR/TDR approved
2014/04	PDR approved
2014/08	Budget approved
2014/12	Ground breaking
2014-2016	**Construction**
2016/12	LINAC commissioning
2017/09	Lasing

SXFEL layout



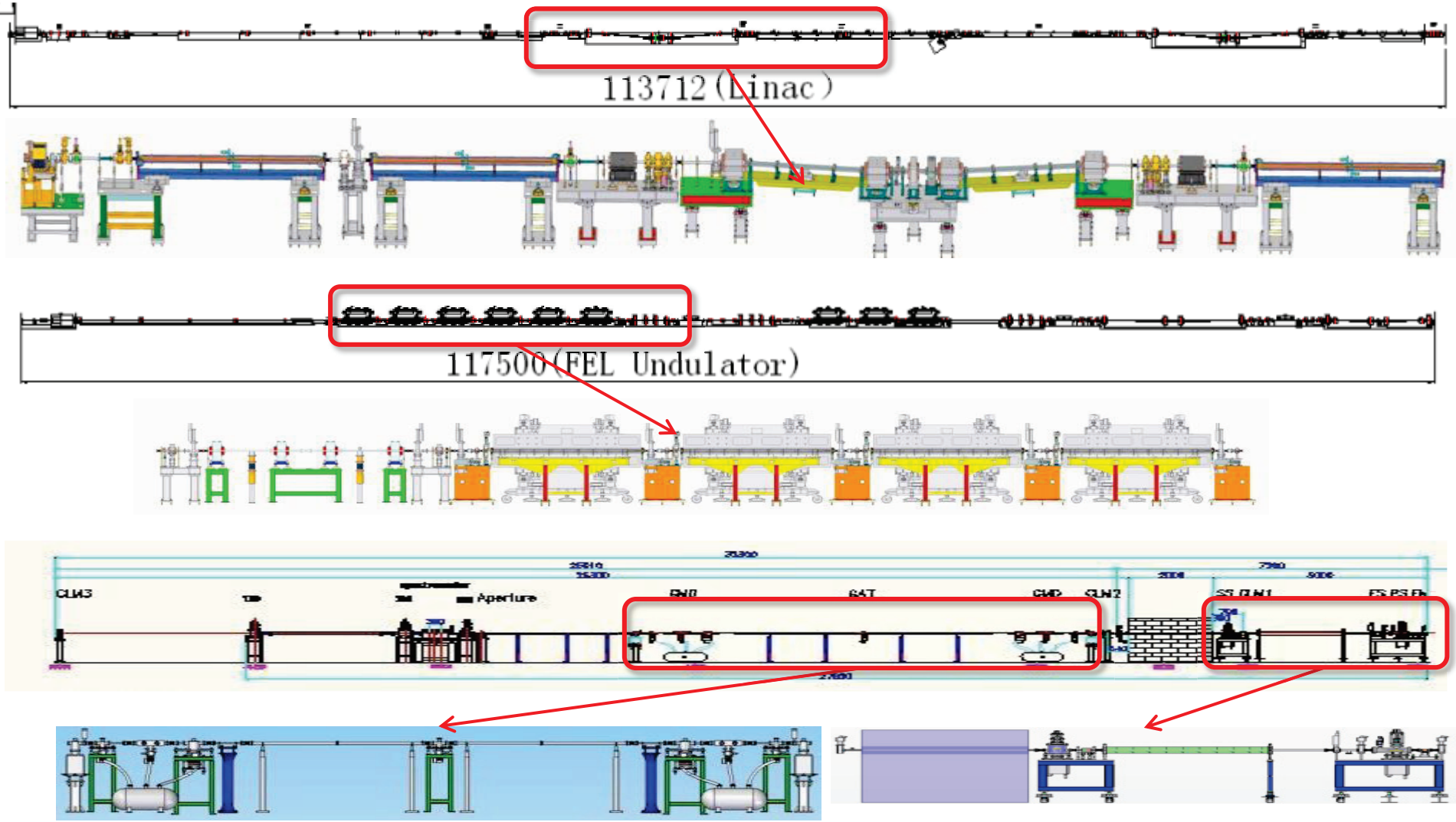


SXFEL layout



- S-band
  - ✓ 4 S-band klystrons
  - ✓ 4 S-band accelerating structures (3m)
- C-band
  - ✓ 6 C-band klystrons
  - ✓ 6 C-band SLEDs
  - ✓ 12 C-band accelerating structures (1.8m)
- 7 Chicanes
- 13 Undulators
- 5 Beam energy spectrometers

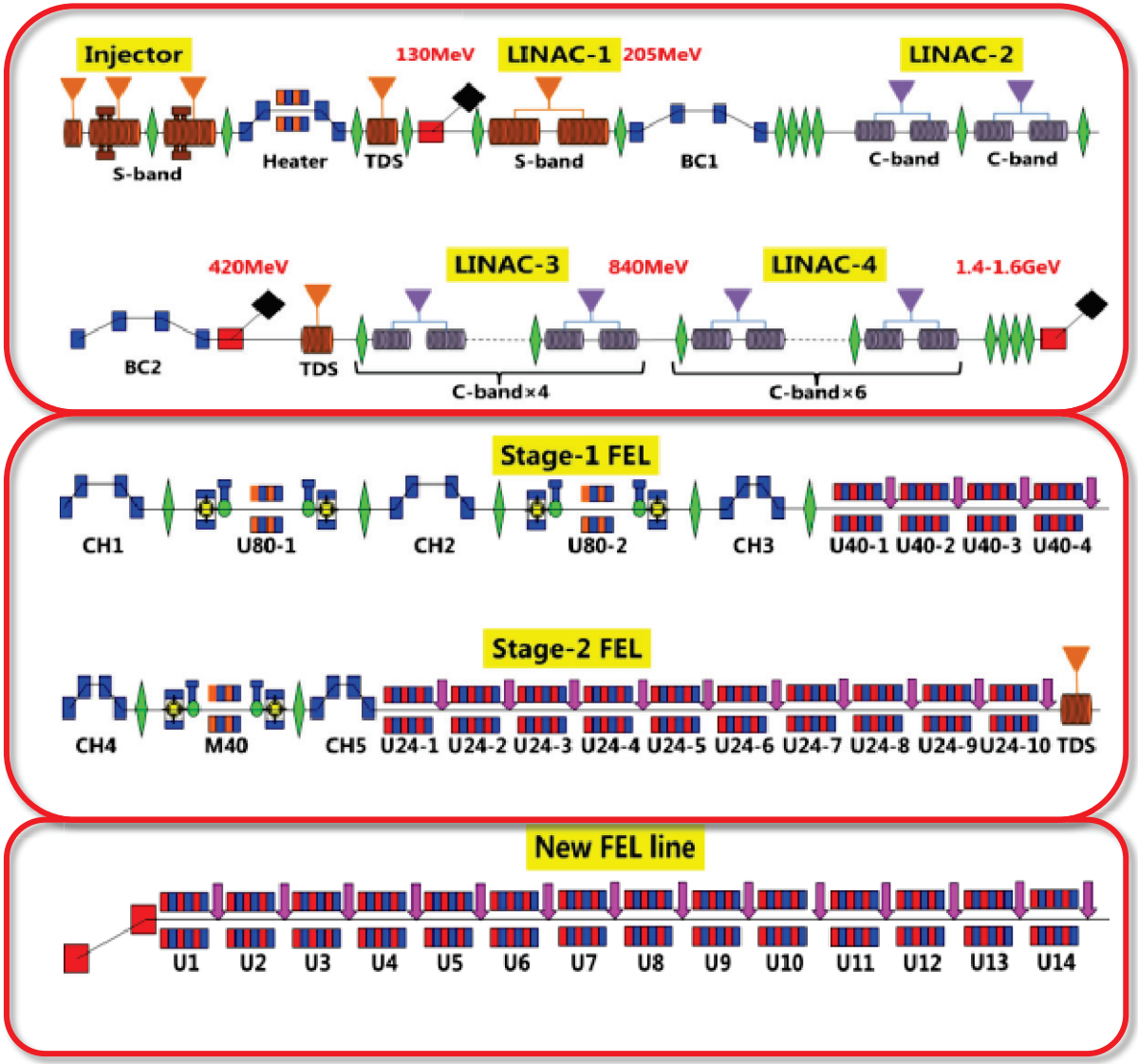
Main Linac, undulator line & diagnostic line



FEL scheme tests and upgrade opportunities

- **HGHG, EEHG, two stages of HGHG**
- **Cascade of EEHG and HGHG**
- Polarization control
- Upgrade to user facility soon
- Integration with high power laser and high brightness gamma-ray source
- Compact hard X-ray user facility
- ……

Upgrade to user facility



Add more accelerating structures to increase the beam energy up to 1.6 GeV

Add more undulators to current undulator line to get saturated 3 nm output

Build a new undulator line to get saturated FEL output at around 2 nm

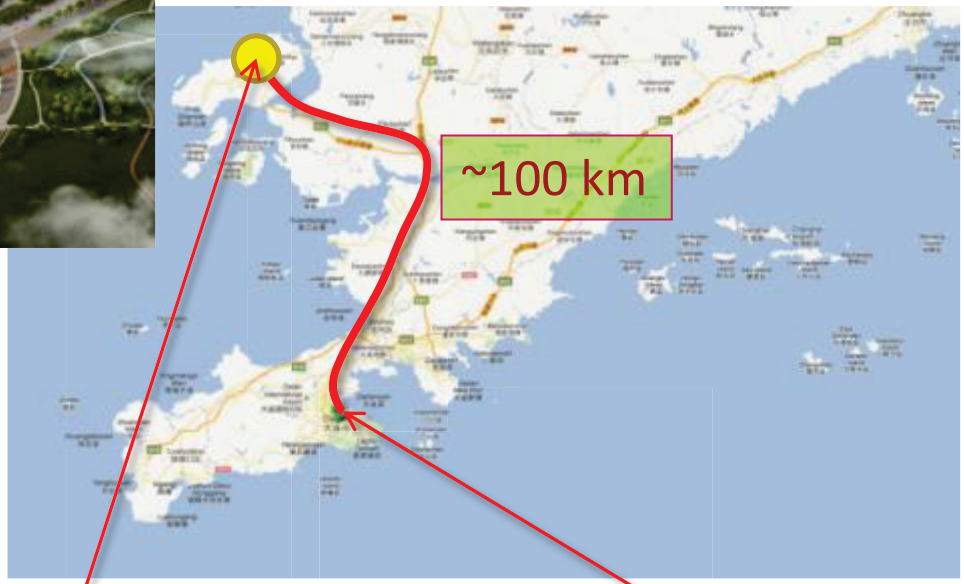
Dalian Coherent Light Source (DCLS)

- Supported by National Natural Science Foundation of China (2011)
- Fully coherent EUV (50-150nm) FEL user facility，HGHG scheme
- Collaborators: DICP、SINAP、USTC
- Groundbreaking: Oct. 2014

DCLS site location

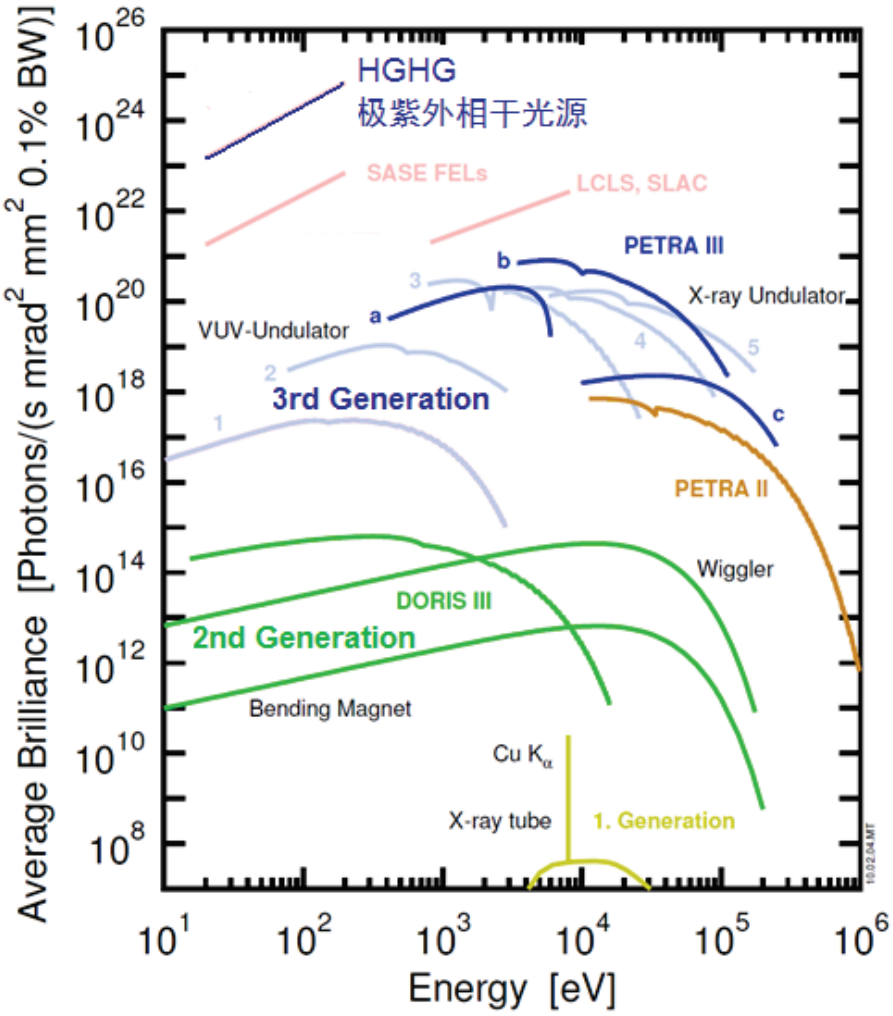
DCLS

Located in the new campus of Dalian Institute of Chemical Physics, CAS

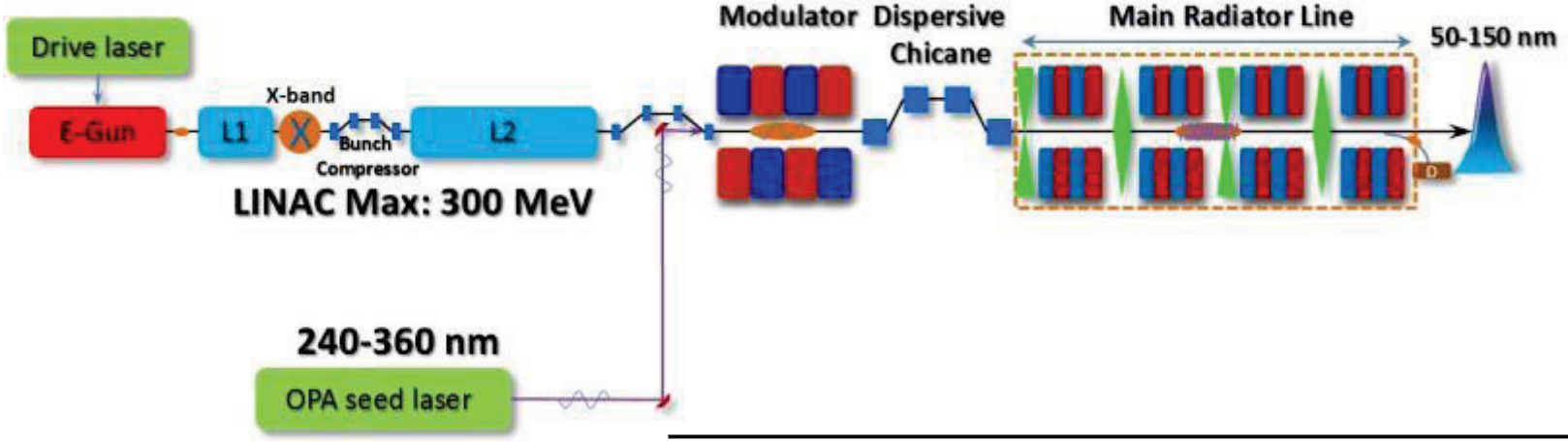


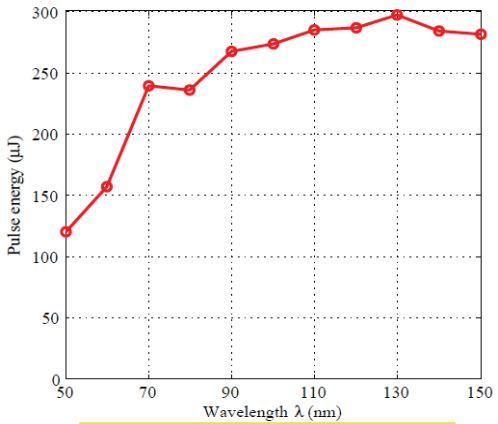
Major opportunities in research

- High Brightness
  - Sensitive Detections of Atomic and Molecular Species
- Ultrafast Characteristics (ps,fs)
  - Probing ultrafast processes of molecules in gas phase and at surfaces



Schematic Layout of DCLS



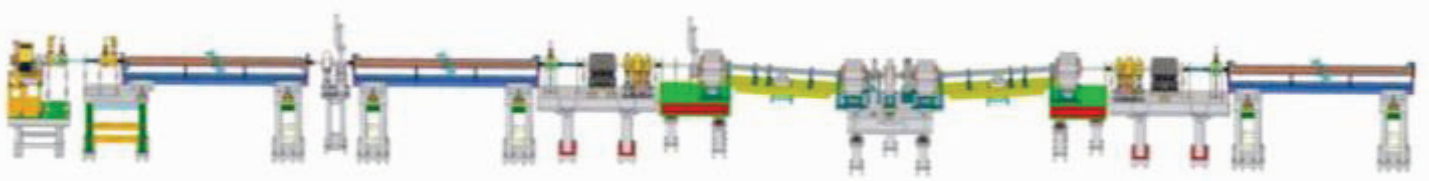


FEL pulse energy

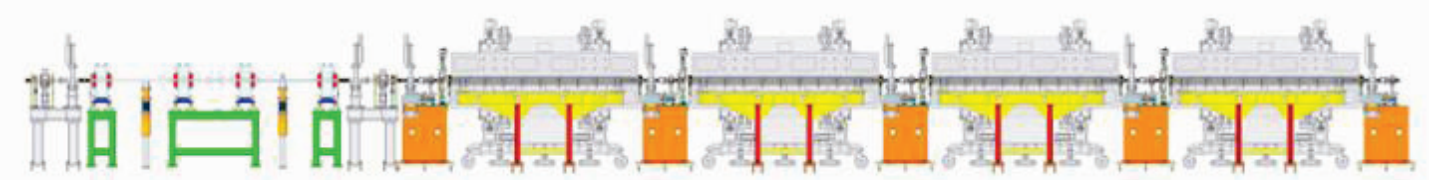
Parameter	Symbol	Value	Unit
Beam energy	E_b	300	MeV
Relative energy spread	σ_δ	1×10^{-4}	
Normalized emittance	ϵ_n	$1 - 2$	mm · mrad
Peak current	I_{pk}	300	A
Seed laser Wavelength	λ_{seed}	$240 - 360$	nm
Seed laser Width (FWHM)	τ_{seed}	1.0	ps
Radiator period length	λ_r	30	mm
Radiator Parameter	a_r	$0.3 - 1.6$	
FEL wavelength	λ_{FEL}	$50 - 150$	nm
FEL Pulse Energy	W_{FEL}	≥ 100	μJ
Photon Flux	F_{FEL}	10^{12}	#/pulse

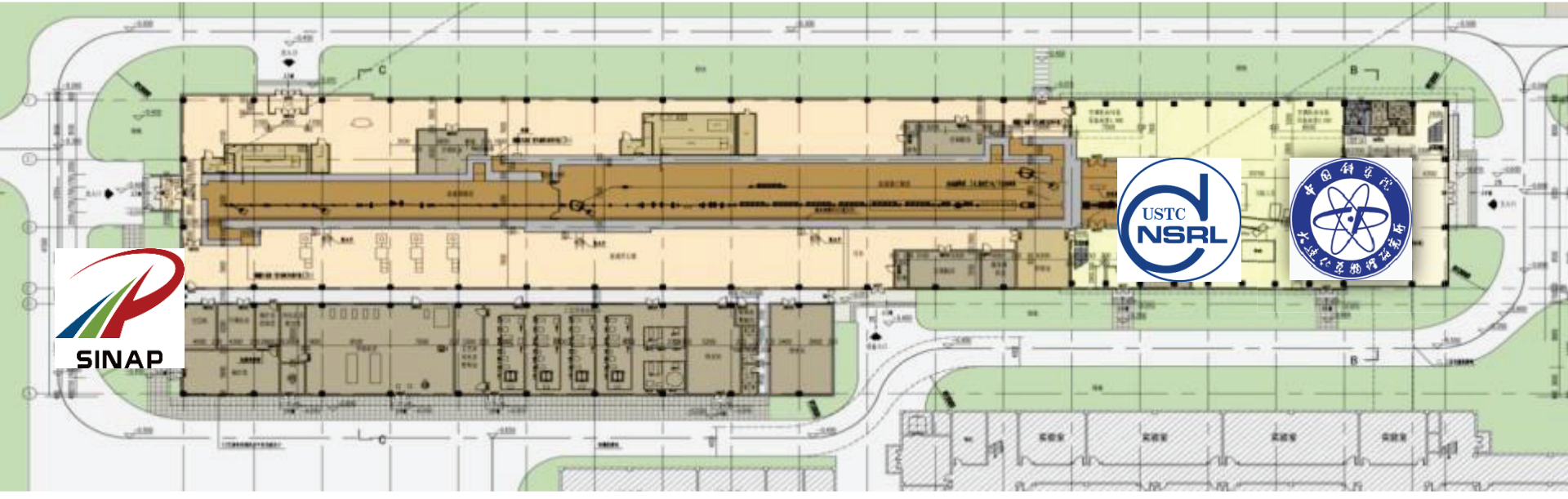
DCLS layout

LINAC



Undulator



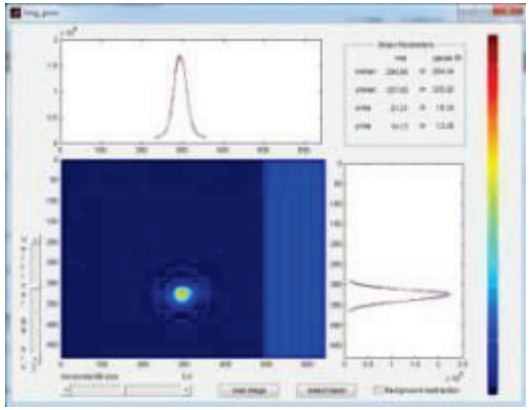


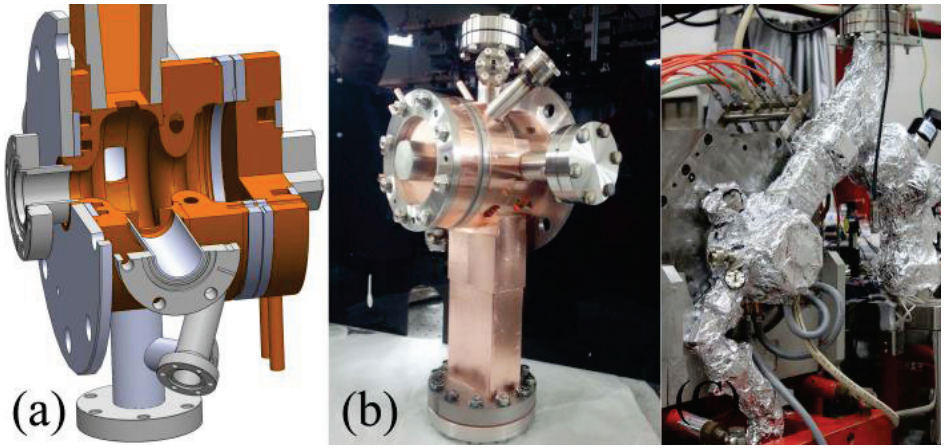
Key component R&Ds

- A set of prototype developments was initiated.
  - **S-band RF Gun**
  - **C-band RF structure and pulse compressor**
  - **Undulator**
  - **Mechanical support**
  - **Small gap vacuum chamber**
  - **Beam diagnostics**
  - **FEL diagnostics**
  - **……**

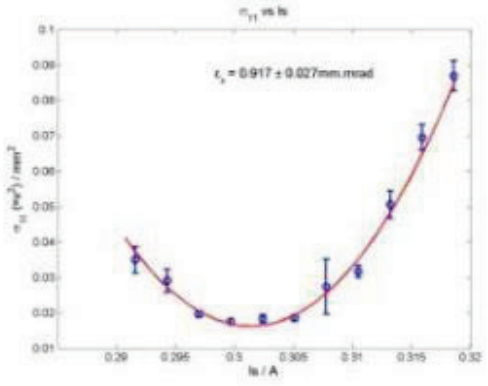
Photocathode RF-gun @THU

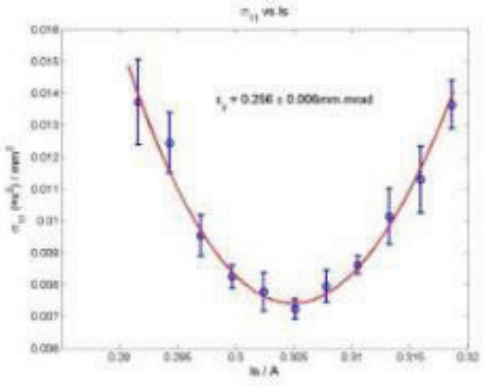
Measurement after 3m-linac @~40MeV





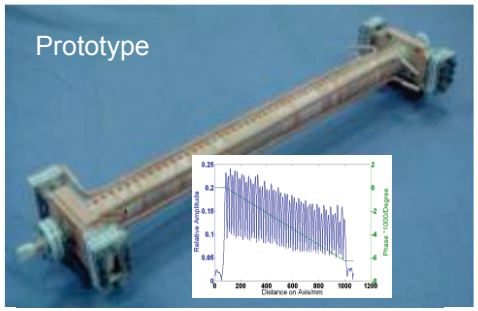
Parameters	Value	Unit
PI mode frequency	2856	MHz
Quality factor Q_0	14000	
Coupling factor β	1.3	
Electric field on cathode	120	MV/m
RF pulse width	1.7	μs
Repetition rate	10	Hz
Peak power of wall heat loss	9.4	MW
Input RF peak power	11.3	MW
Cathode material	Copper	
QE	4×10^{-5}	
dark current at 120 MV/m	< 250	pC/pulse

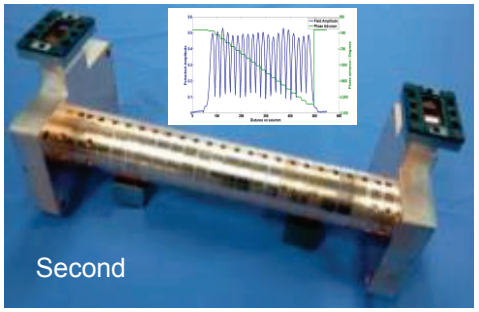


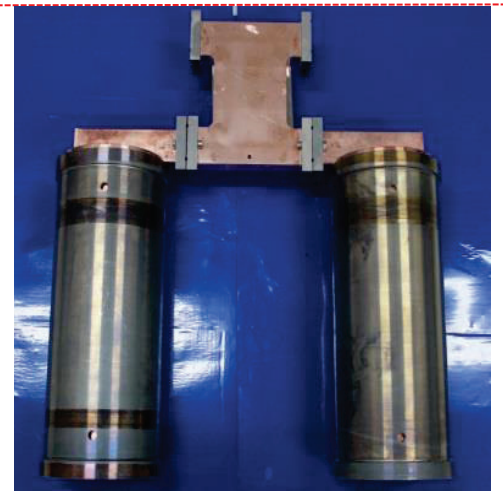


C-band RF structures

- C-band accelerating structures
- C-band pulse compressor
- RF source and LLRF

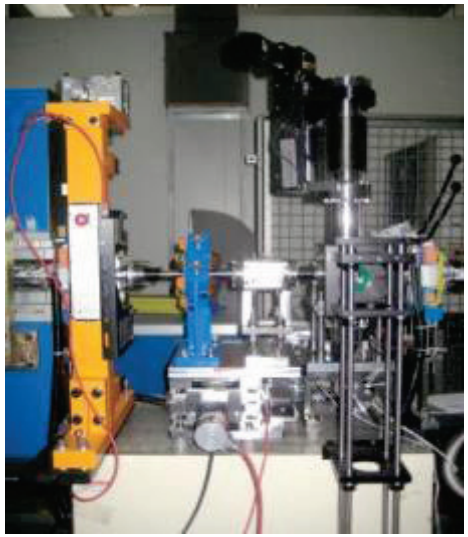
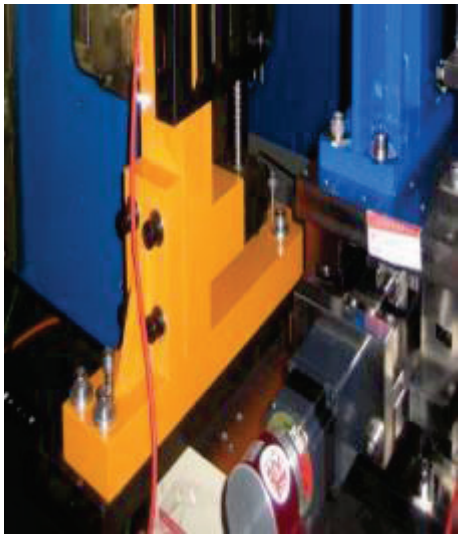




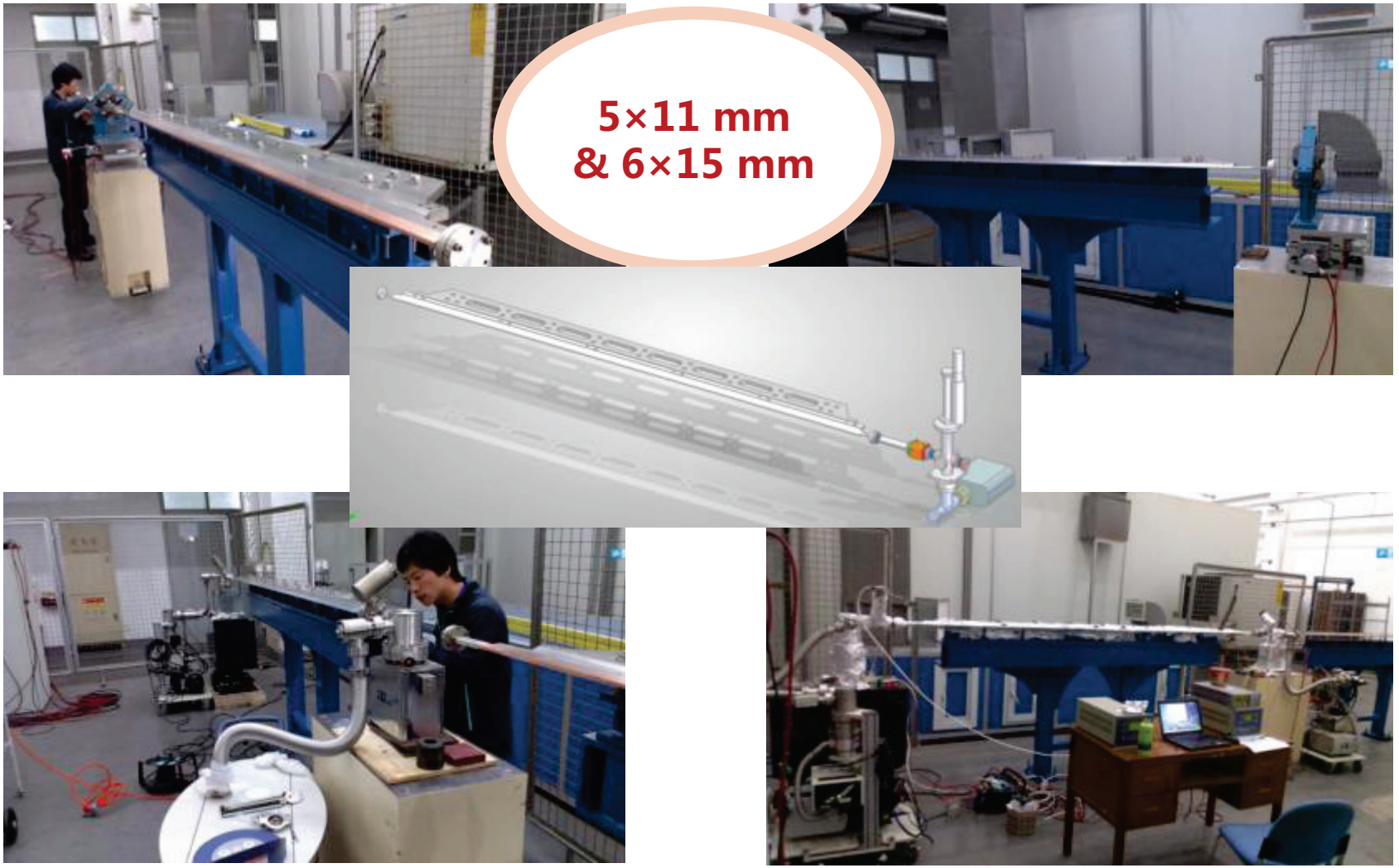


1.8 meters C-band accelerating Structure for SXFEL

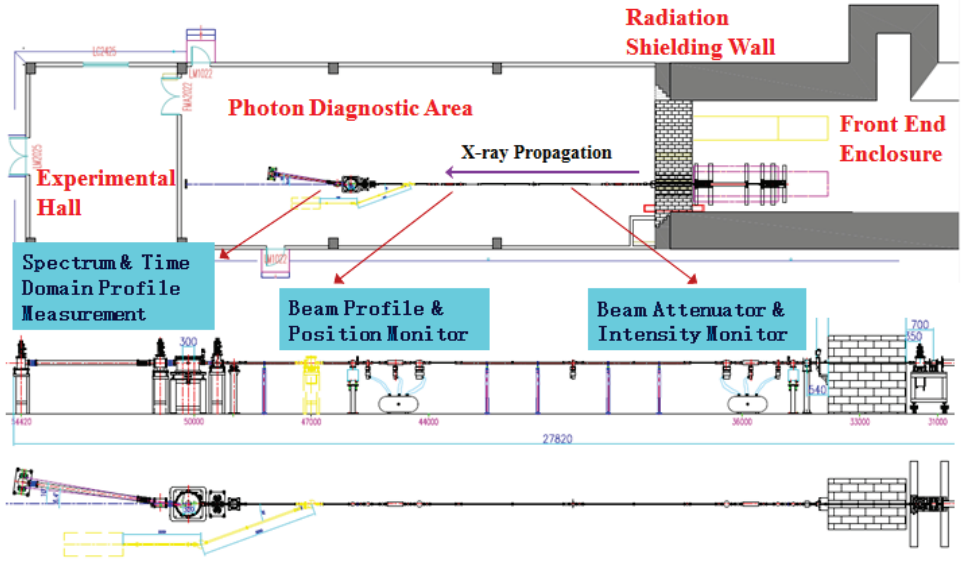
Undulator module demo

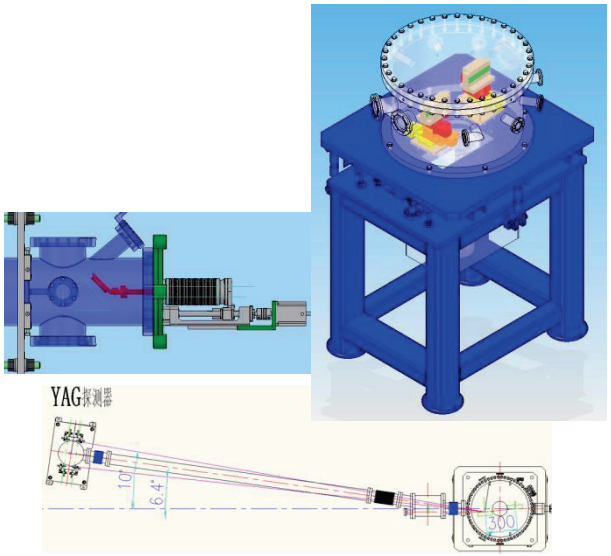




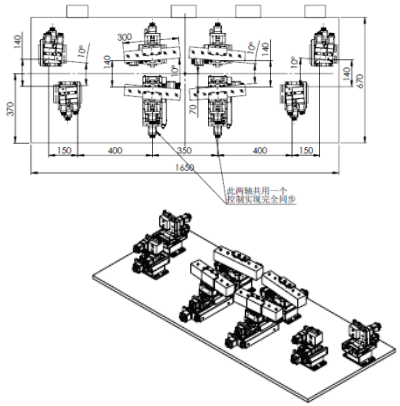
Undulator vacuum chamber prototype

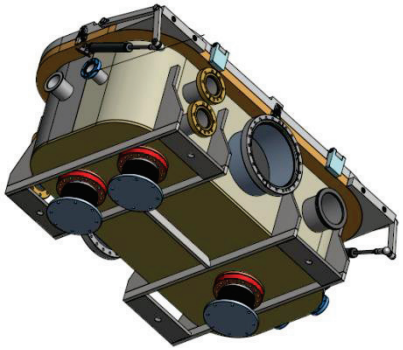


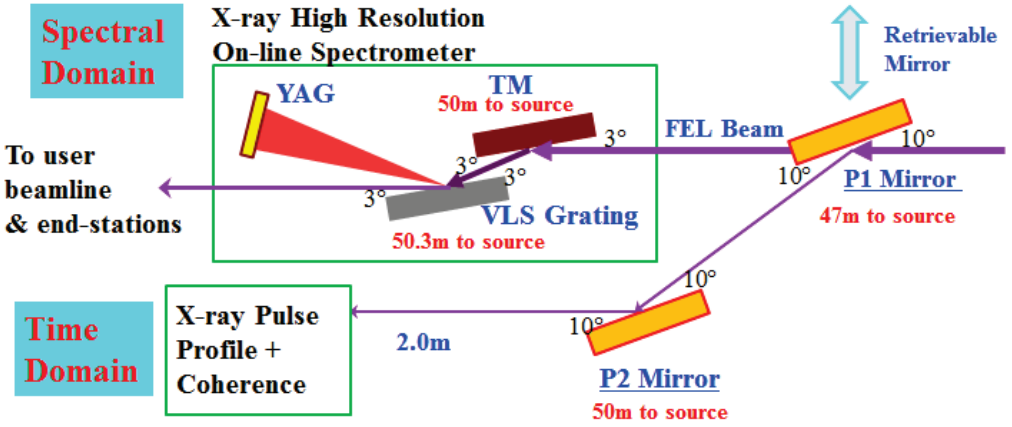
Diagnostic beamline









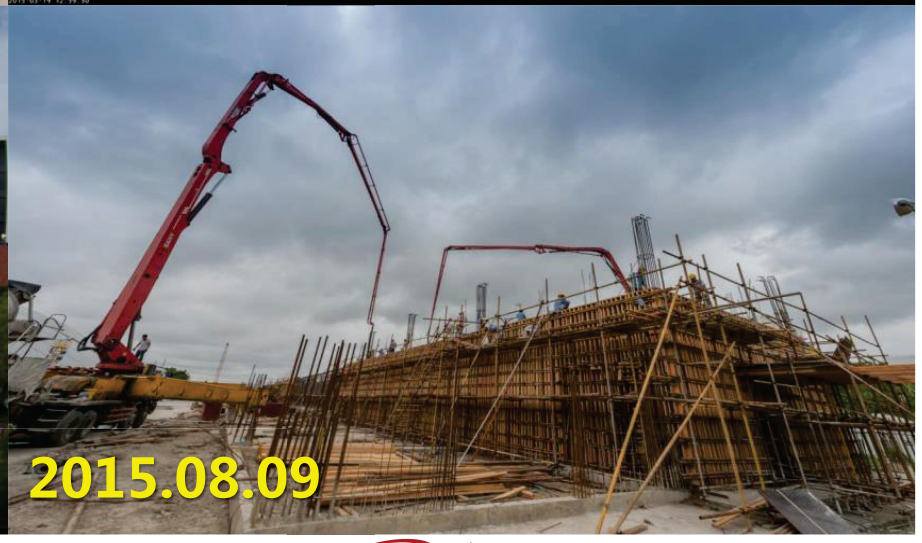


SXFEL construction photos

2014.12.30


2015.03.19

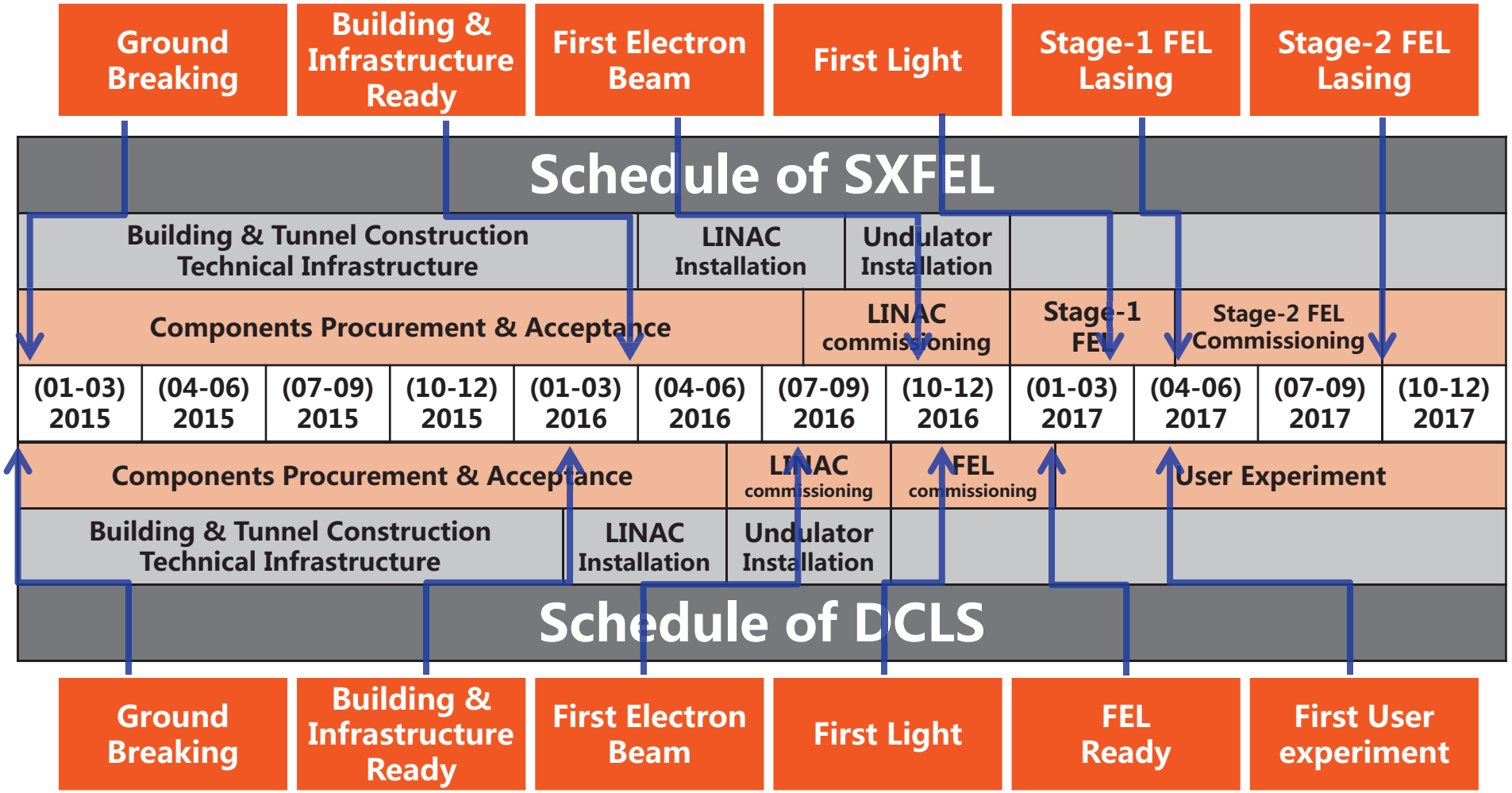

2015.06.04


2015.08.09

SXFEL construction photos

DCLS construction photos

Status of the projects



In general the schedules are really tight.
DCLS is about 3 months ahead of SXFEL.
So far, the projects are on schedule.

Conclusions

- Two high-gain FEL facilities, i.e., DCLS & SXFEL are now under construction.
- Key technologies have been tested through prototype developments.
- The building and infrastructure will be ready soon. Both projects proceed as scheduled and are expected to lase in 2017.
- SINAP is making great efforts to upgrade SXFEL to a user facility.

Thanks for your attention!