Commissioning and First Lasing of Dalian Coherent Light Source

Weiqing Zhang on behalf of DCLS team

Dalian Institute of Chemical Physics, CAS

FEL2017， 2017.08.21


Lake Baikal
Amur
Harbin
Shenyang
NORTH KOREA
SOUTH KOREA
BEIJING
Tianjin
Yellow Sea
Huang He
Zhengzhou
Shanghai
Nanjing
Xi'an
Wuhan
East China Sea

Dalian


大連相干光源
Dalian Coherent Light Source

High Gain FEL

	Length	Energy GeV	Budget ($)
Dalian	150m	0.3	~25 m
Shanghai	300m	1.0	~35 m
Fermi	350m	1.2	~0.18b
FLASH	400m	1.2	~0.3 b
SwissFEL	715m	5.8	~0.4 b
SACLA	750m	8.0	~0.4 b
PAL-XFEL	1.1km	10.0	~0.4 b
LCLS	1.5km	14.5	~0.4 b
LCLS-II	1.5km	4.0	~1 b
European XFEL	3.8km	17.5	~1.5 b

VUV

Soft X-ray

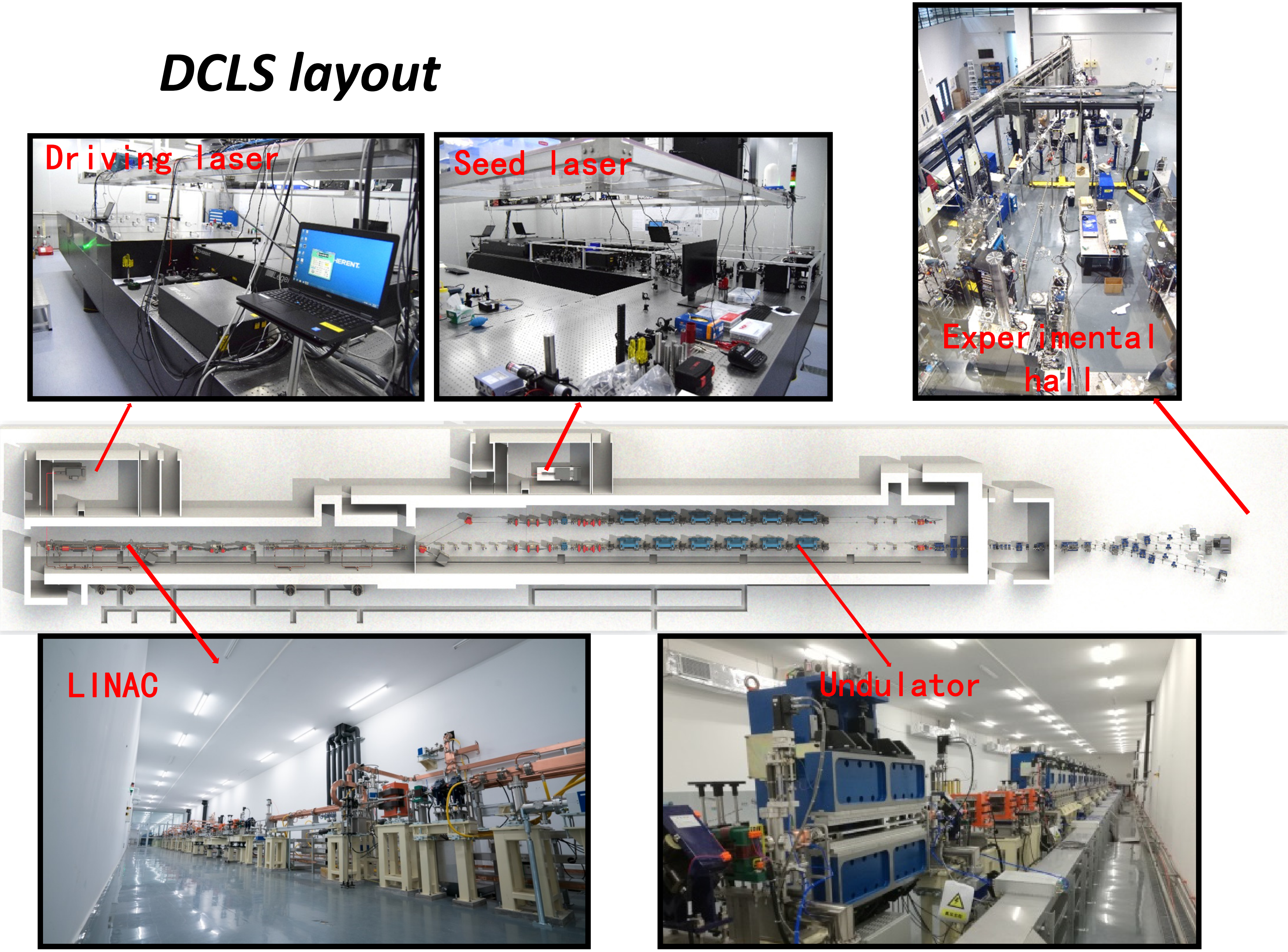
Hard X-ray

SC FEL

Key number of DCLS

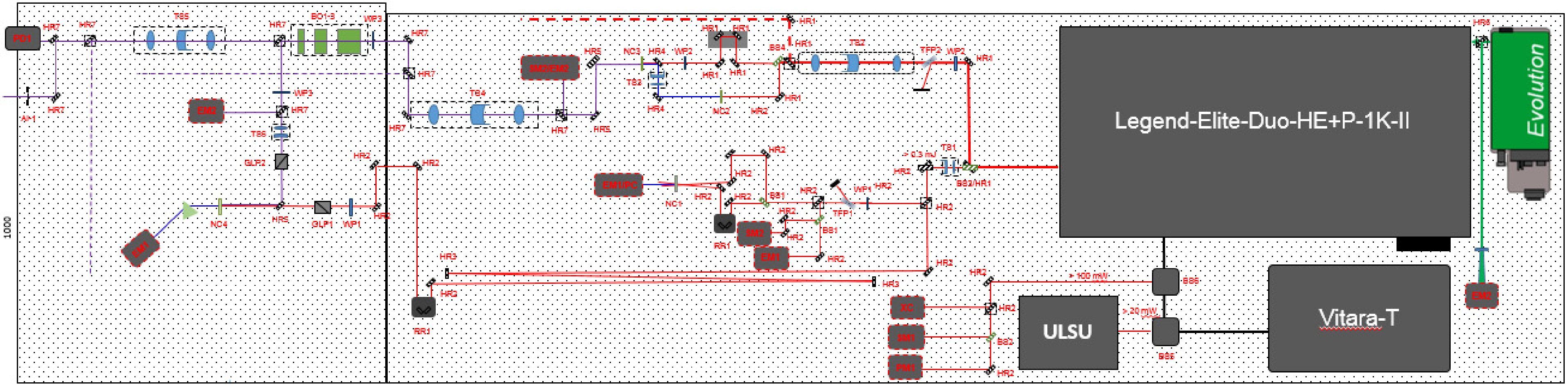
- **Tunable Wavelength： 50 – 180 nm**
- **Pulse Energy： >100 uJ (1 mJ)**
- **Pulse length： 100 fs /1 ps**
- **Bandwidth： Fourier transform limit**
- **Jitter： <30 fs**
- **Rep Rate： 50 Hz**

DCLS layout

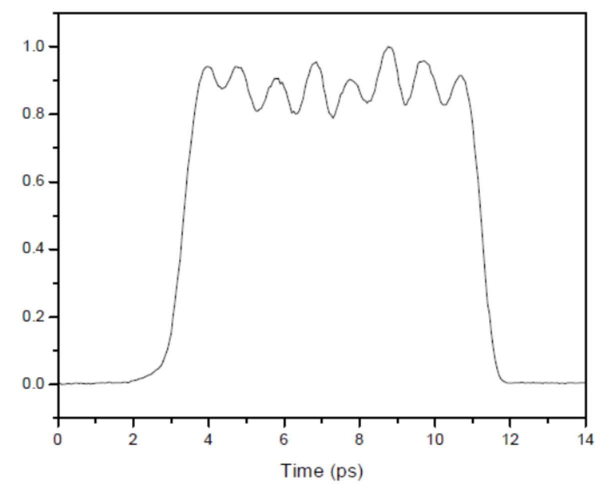

Driving laser
Seed laser
Experimental hall
LINAC
Undulator

Driving laser system

Poster number: WEP001

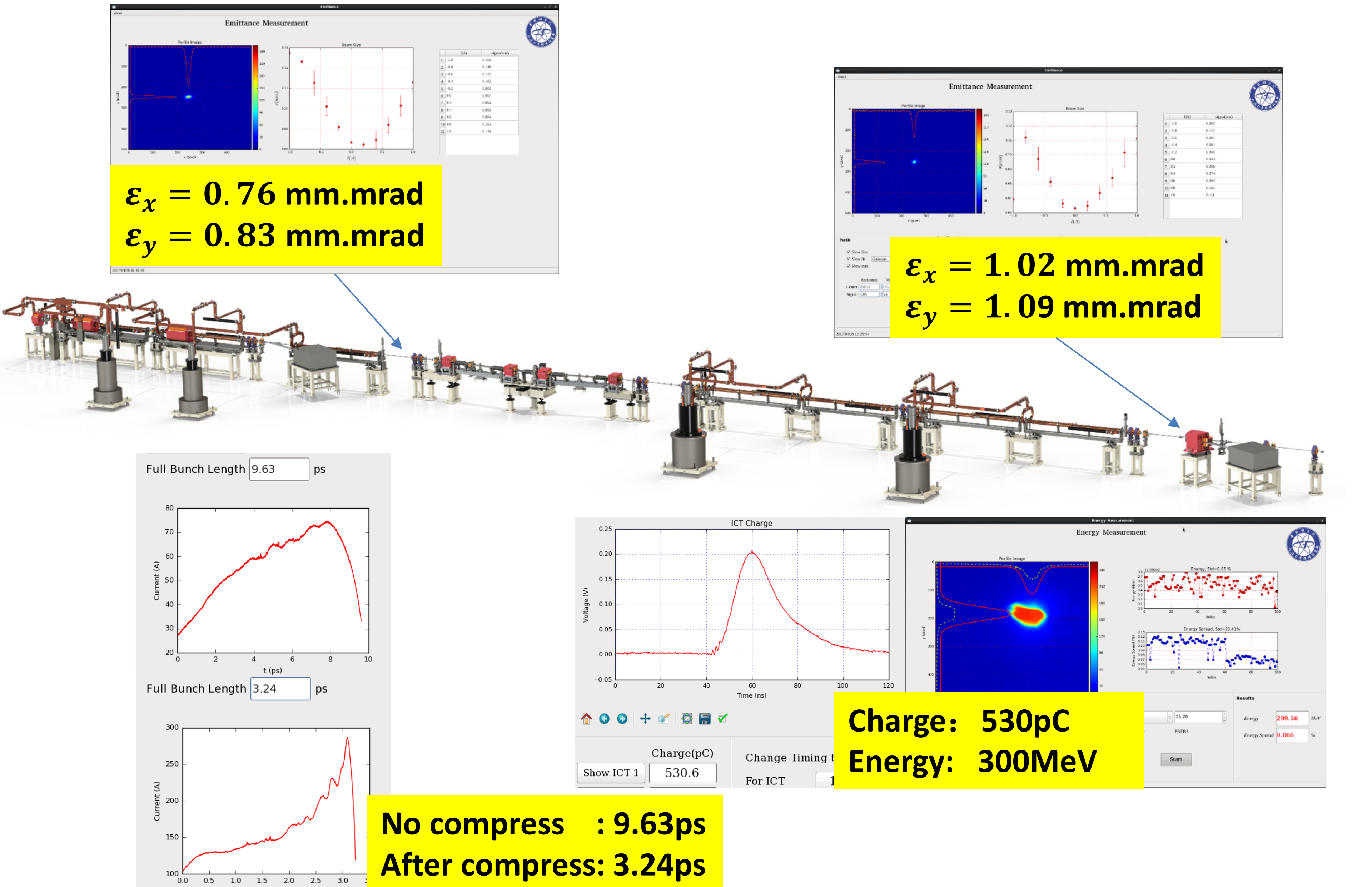


	Design	Achieved
Wavelength (nm)	260	259.58
Rep rate (Hz)	1-50	1-100
Pulse energy (μJ)	250	300
Energy stability (rms)	2.00%	0.90%
Spot size (mm)	1.3~2.6	2
Position stability (μm)	20	7
Longitudinal distribution	Flat top	Flat top
Pulse length (ps)	7	7



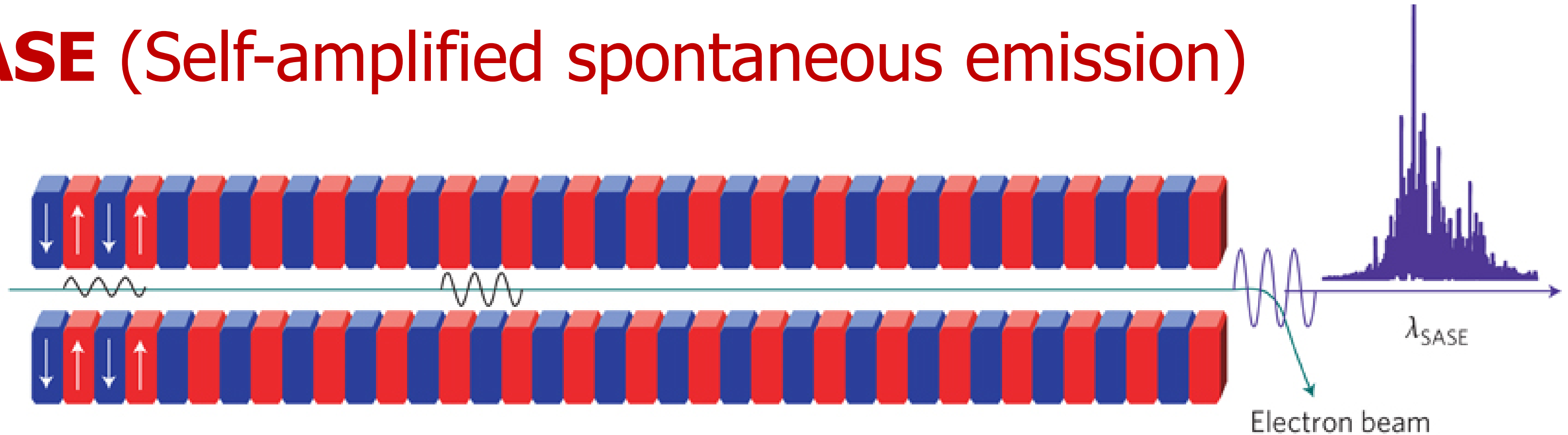
Longitudinal distribution

LINAC result



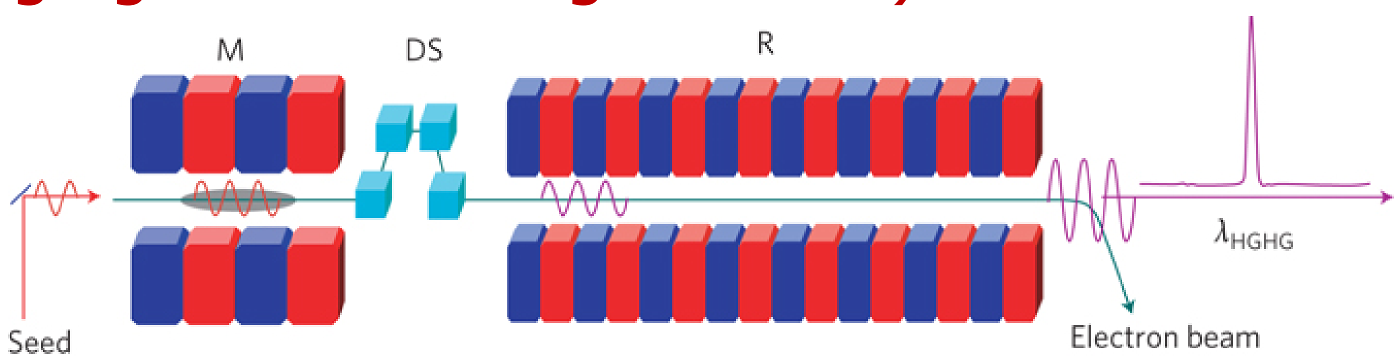
FEL Mode

a) **SASE** (Self-amplified spontaneous emission)



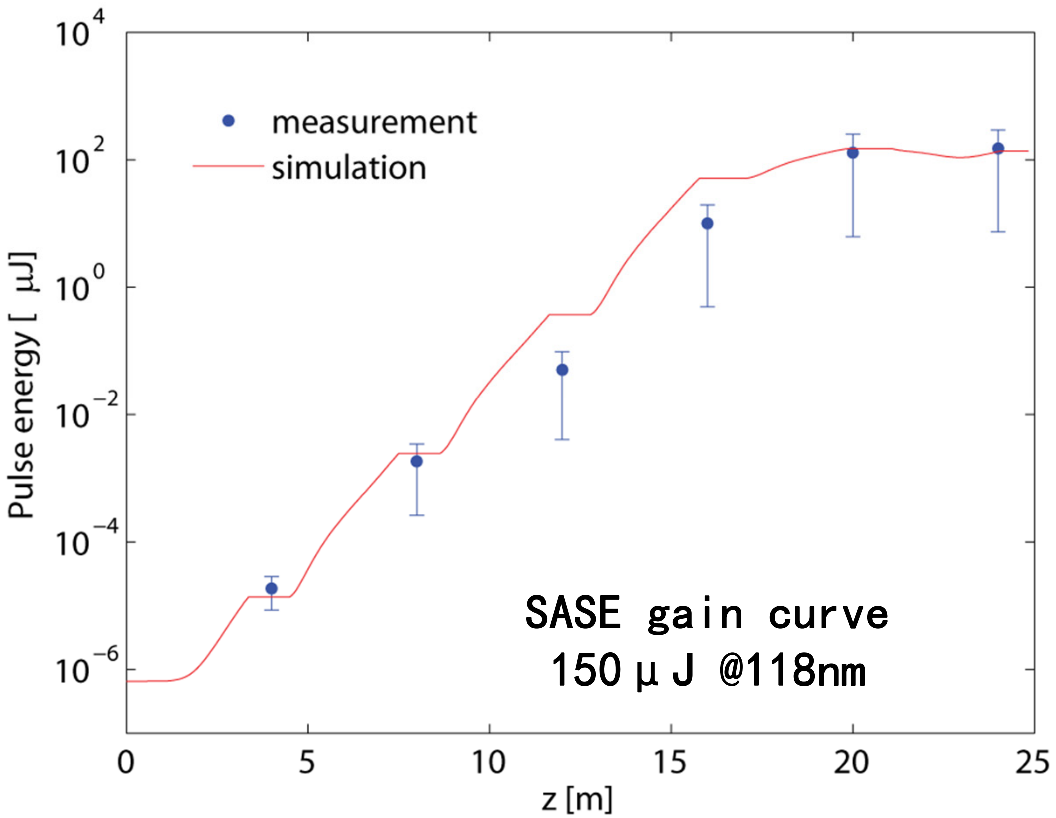
S. Milton *et al.*, Science **292**, 2037 (2001)

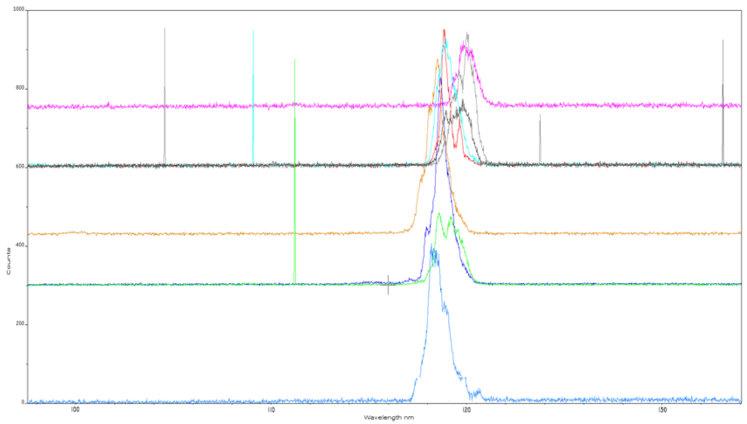
b) **HGHG** (High gain harmonic generation)



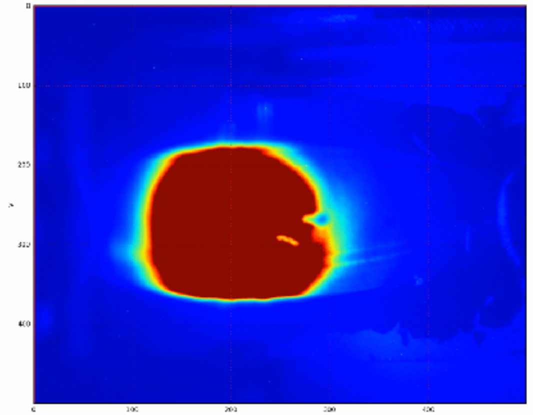
Yu et al, Science 289, 932(2000)

SASE at DCLS





SASE spectrum

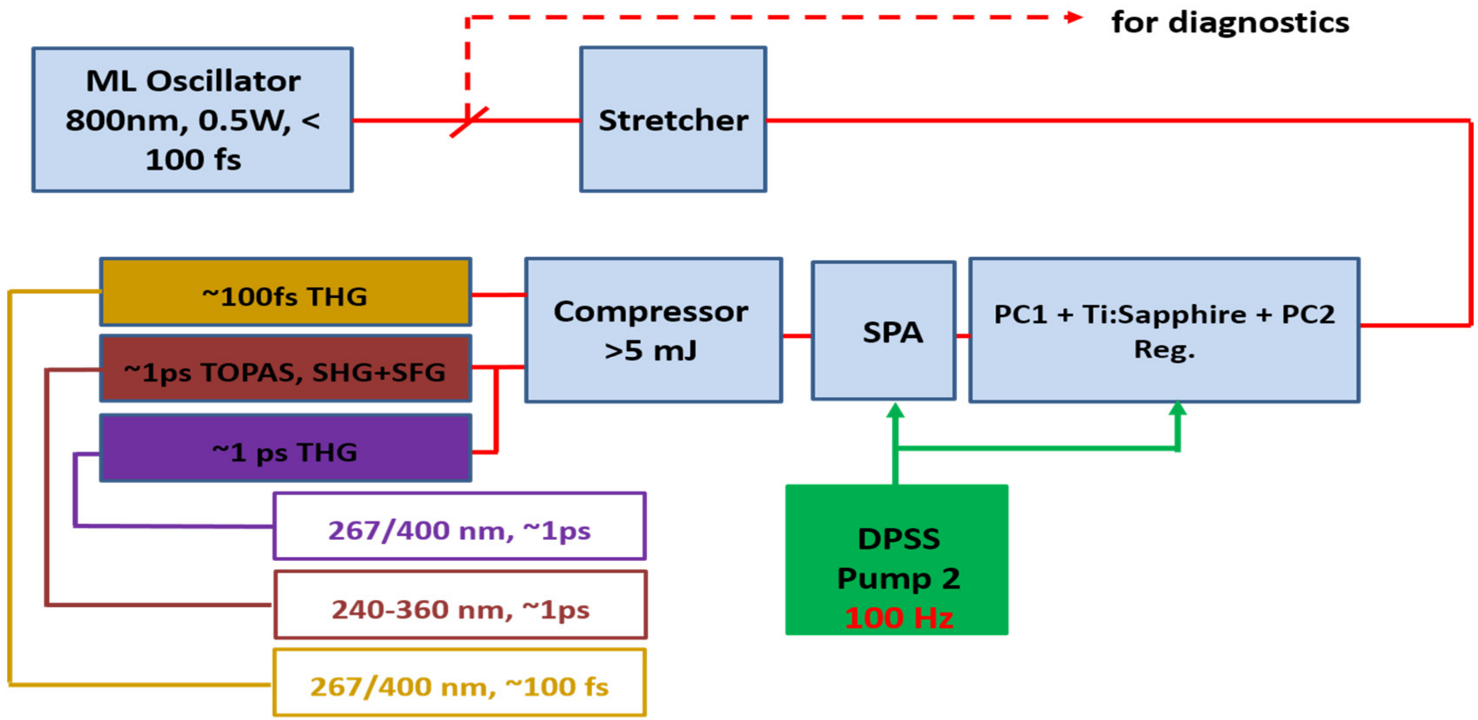


SASE spot image

>100μJ @ 90nm 118nm and 148nm

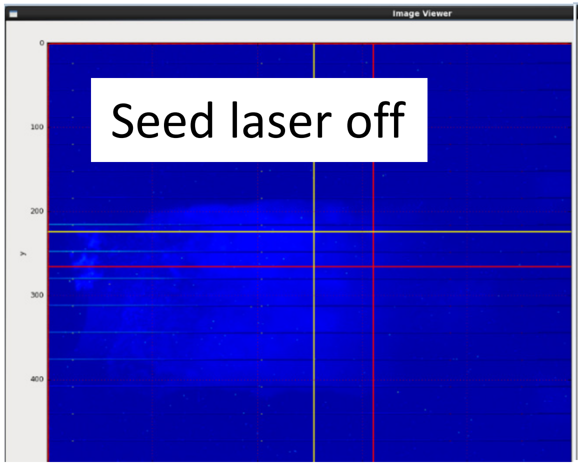
Poster number: WEP001

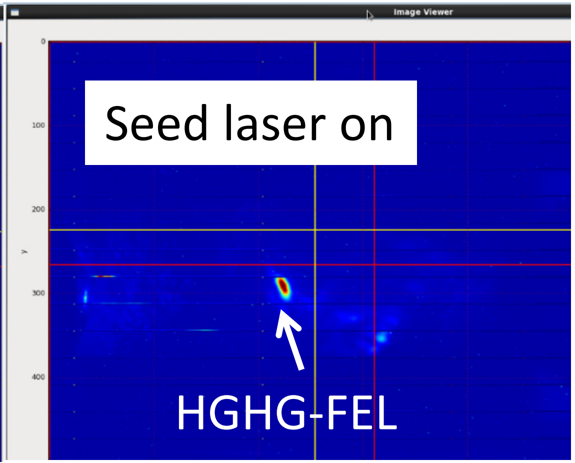
Seed laser system

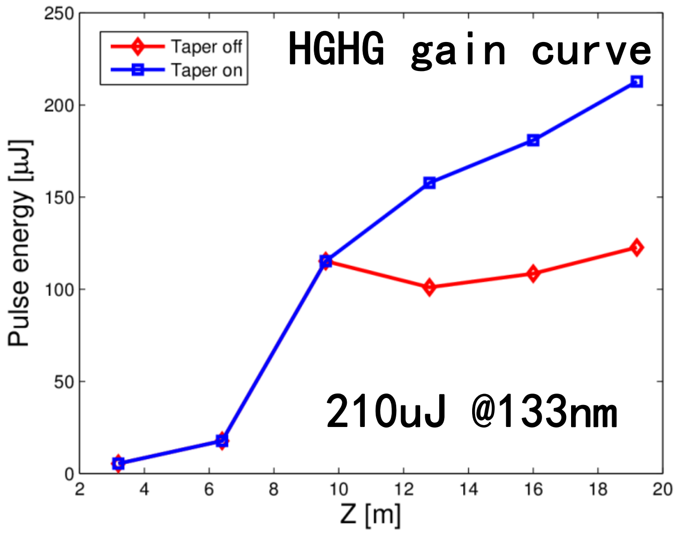


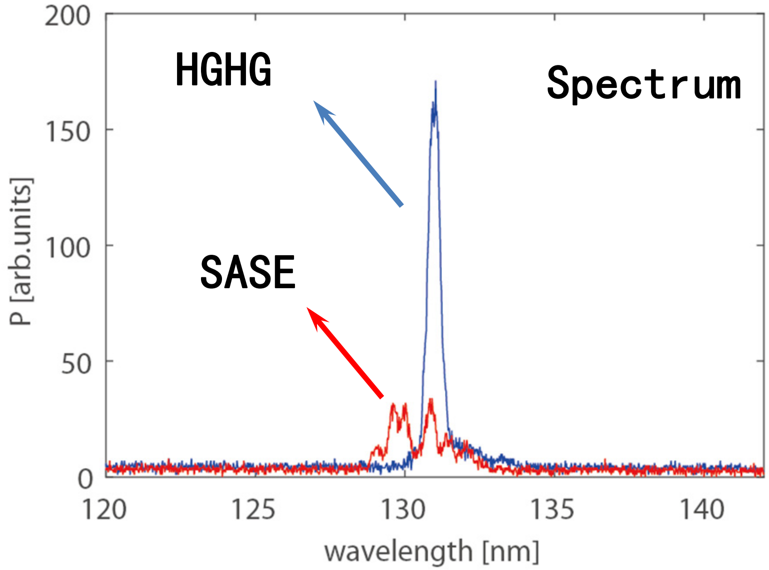
	Design	Achieved
Wavelength	240 – 360 nm	240-360 nm
Pulse energy (μJ)	>40 @1 ps	170
Beam size (mm)	2	2.6
Pulse duration (ps)	1	~1.2

HGHG at DCLS



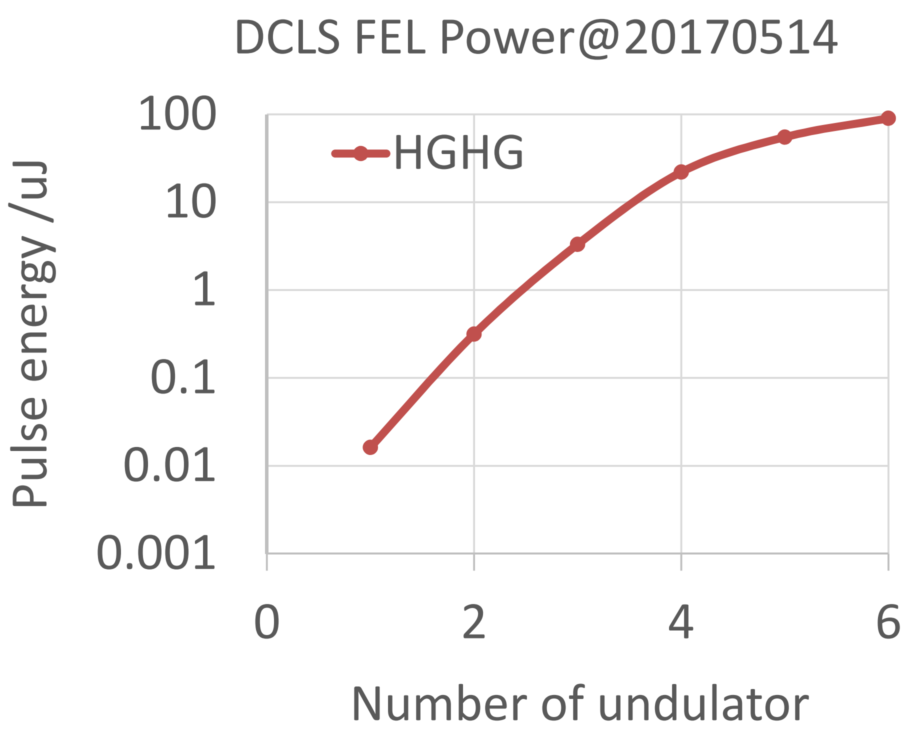


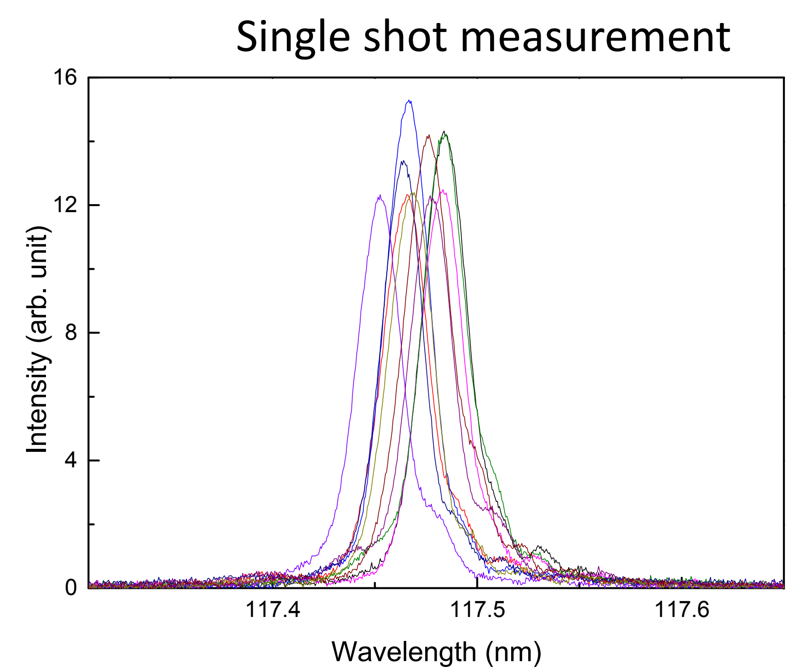




Seed laser is 266nm, which is 3rd of 800nm.
88nm (3rd harmonic of seed laser) is also achieved, energy is about 30uJ.

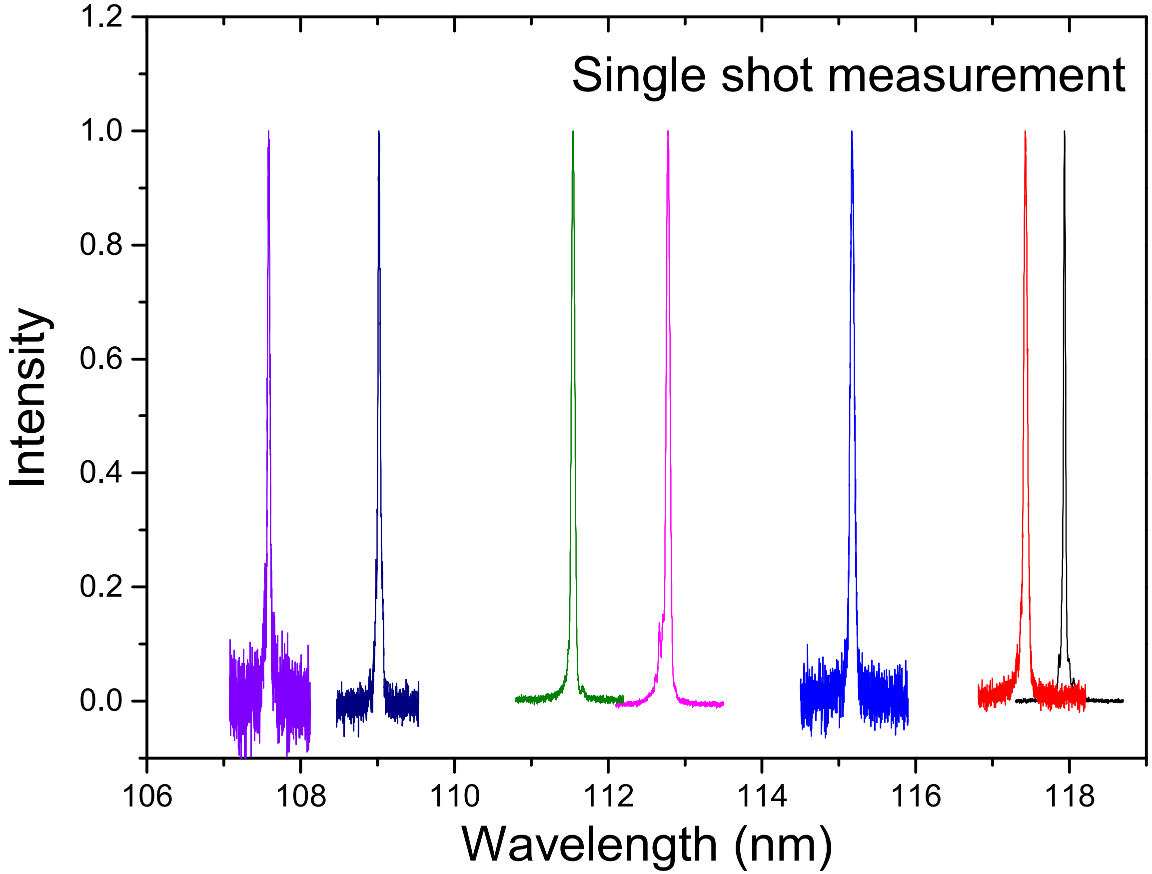
DCLS with OPA seed laser





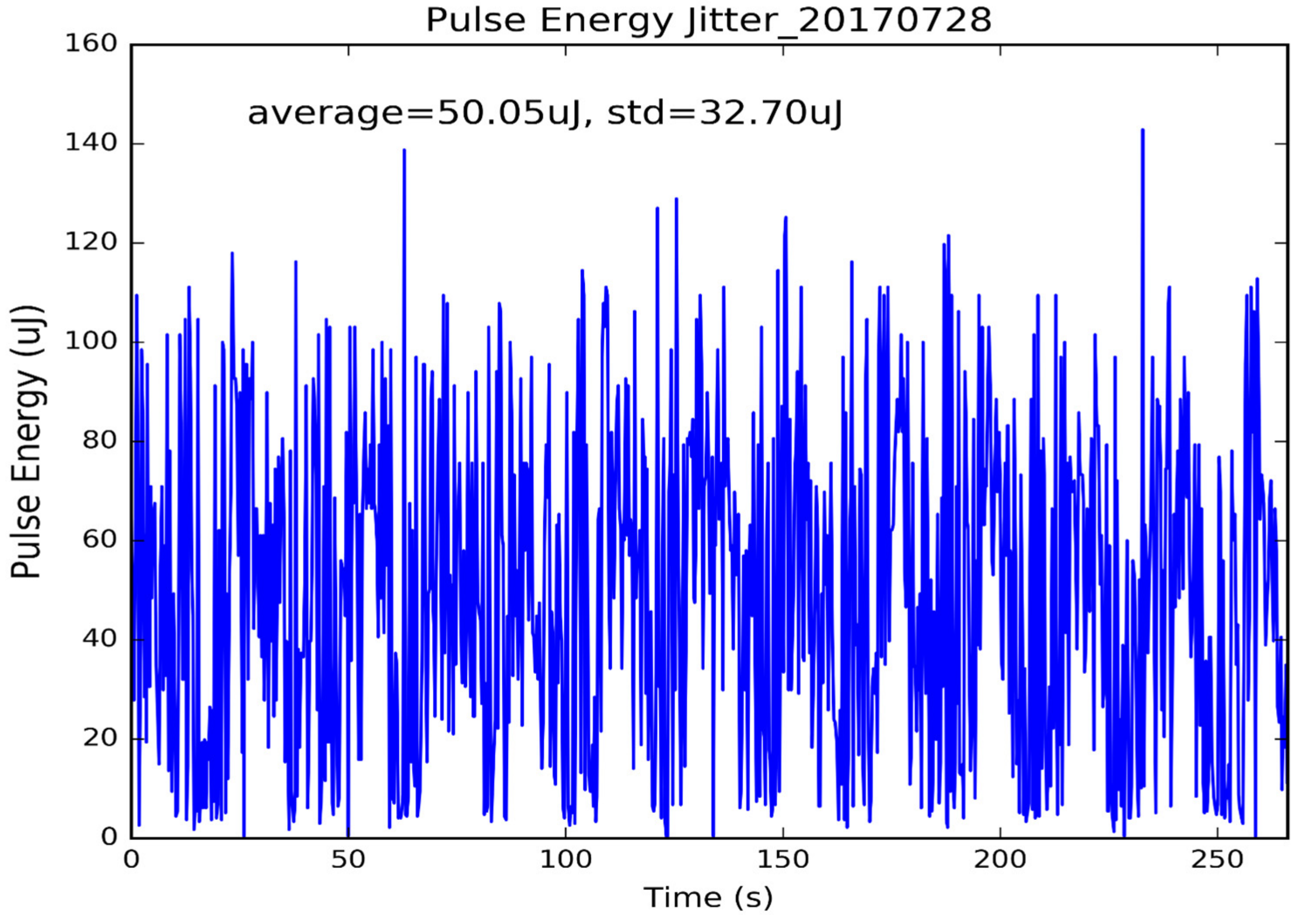
The bandwidth is less than 0.05%, however jitter of wavelength is about 0.1nm, which is from timing jitter and electron energy jitter.

Tunable wavelength



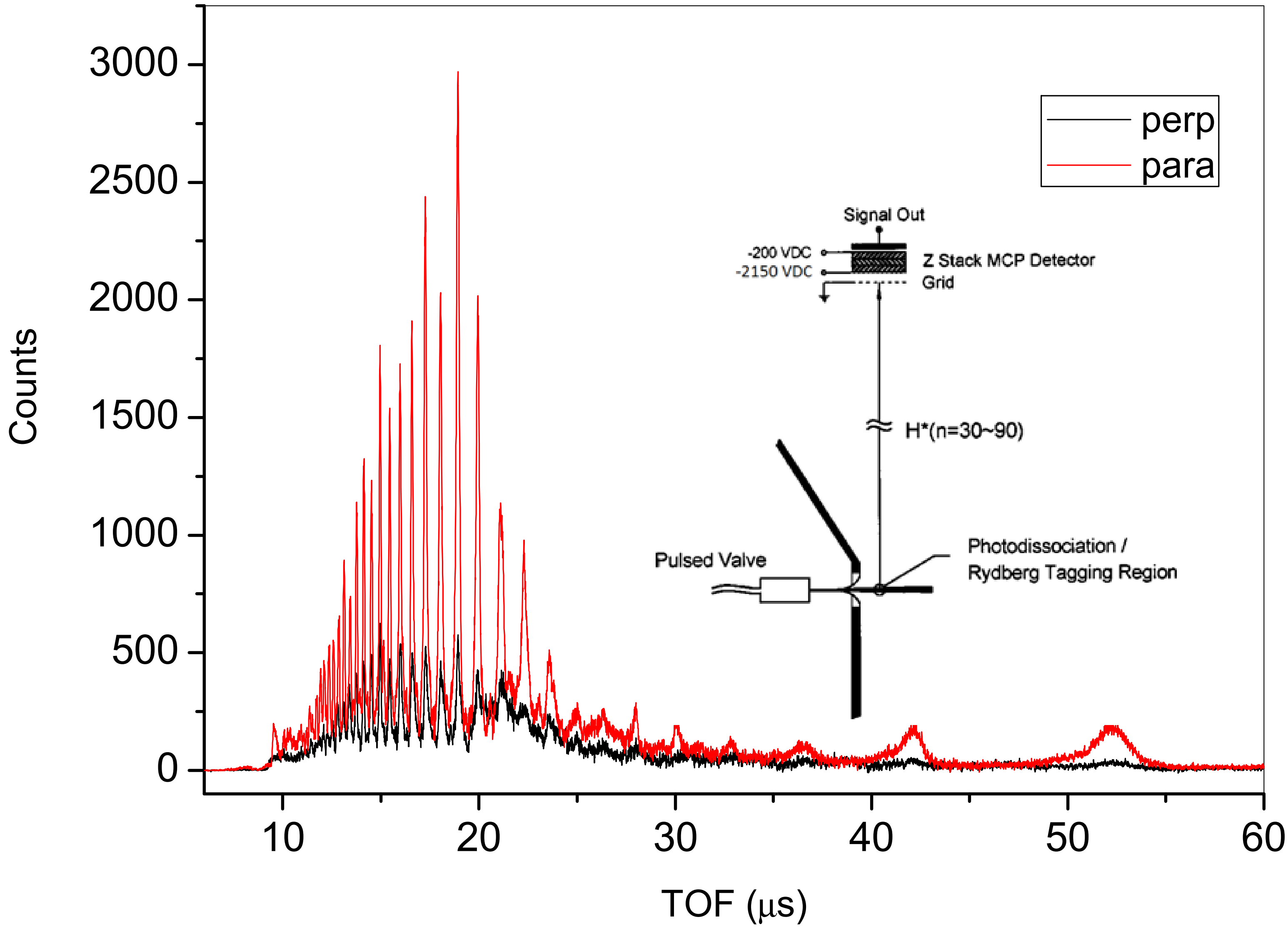
FEL is tunable with OPA. 3rd harmonic of seed laser is amplified via FEL process, which is from 106-118nm.

Energy stability



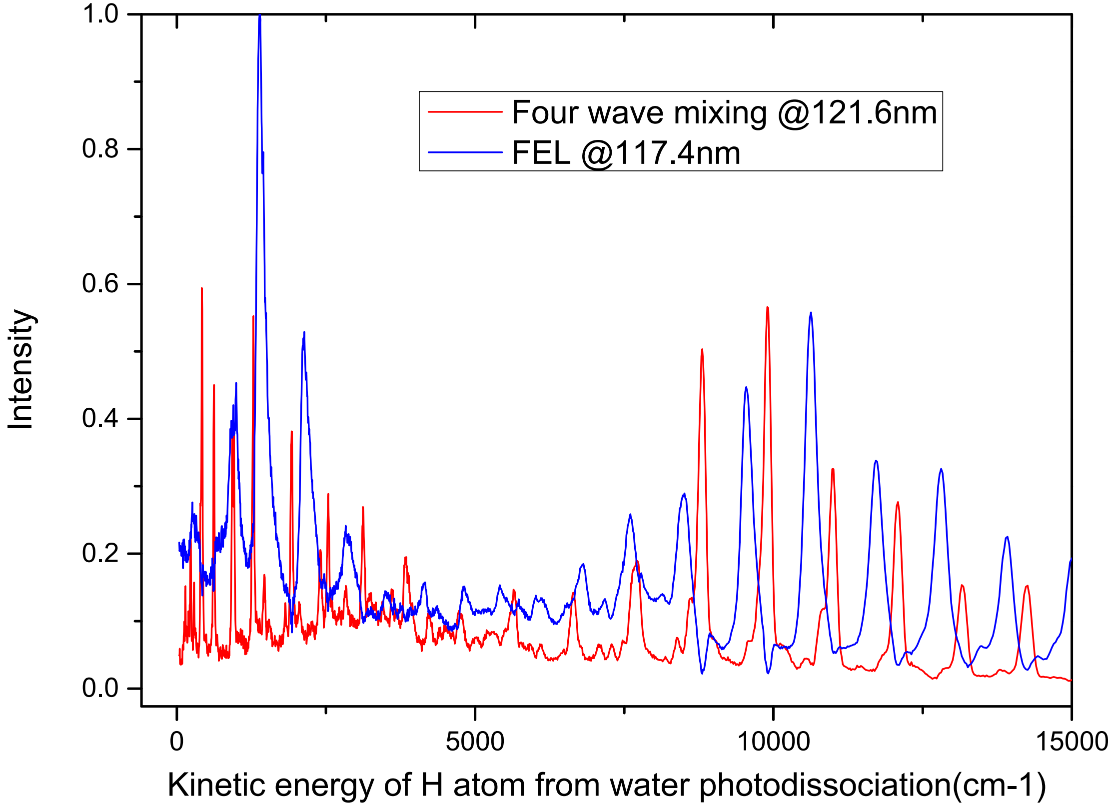
The energy is not as stable as expected for HGHG FEL. Synchronization of seed laser & e beam, spatial overlap of each other, e beam energy jitter

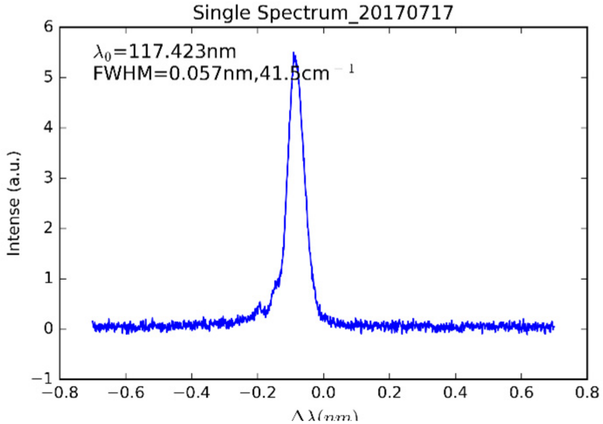
First user experiment

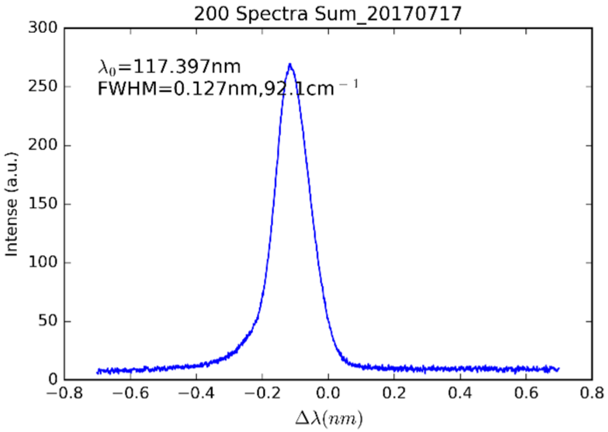


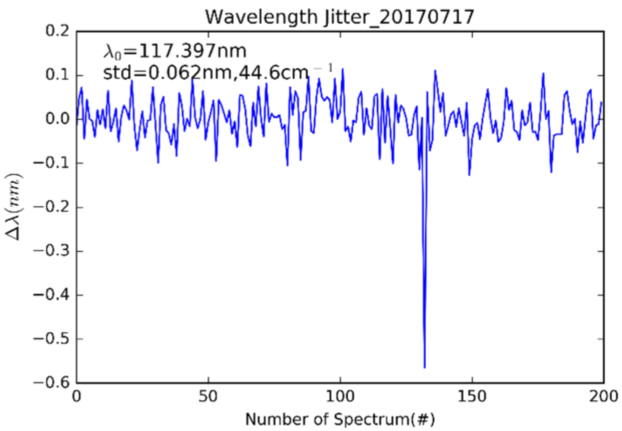
H2O photodissociation at 117.5nm (FEL VUV)

Data analysis





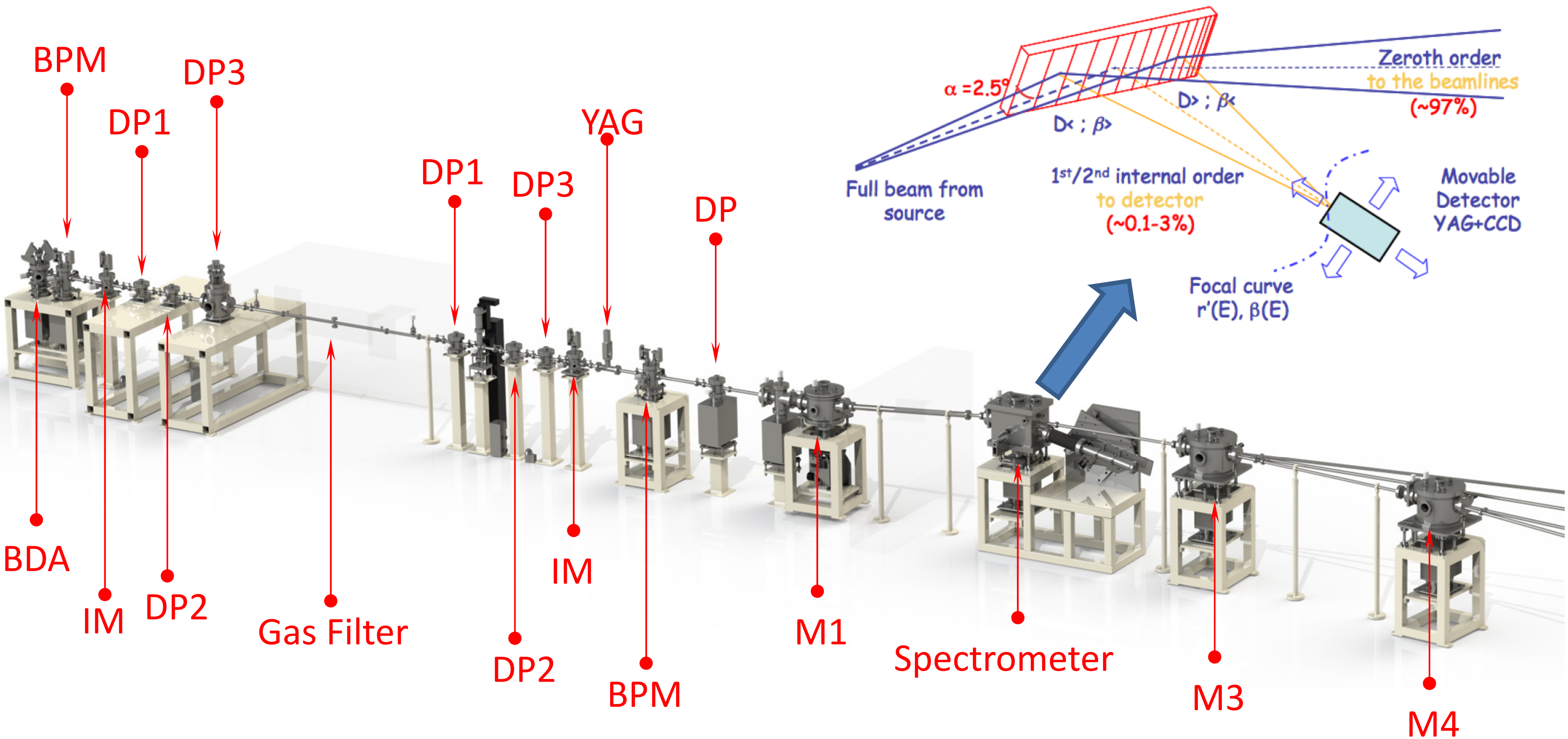




Spectrum peak FWHM using FEL is about 200cm^{-1}, which is much larger than four wave mixing.

Photon diagnostics and delivery system

FERMI, Italy



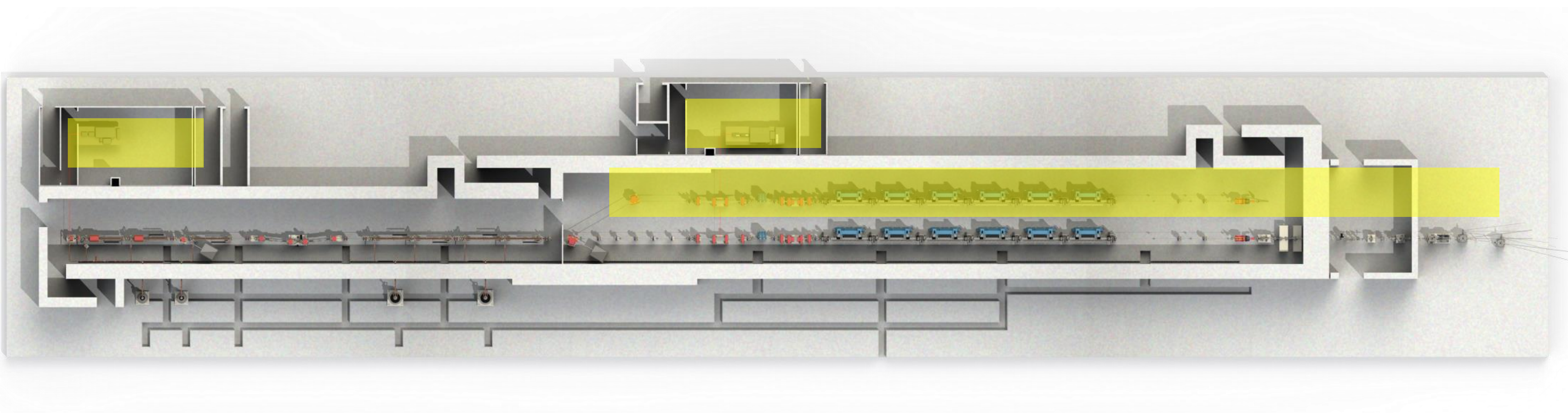
- **Photon Beam position, intensity, wavelength will be recorded in real time.**
- **Estimated beam transfer efficiency is about 85% after 2 mirrors.**

Key number of DCLS

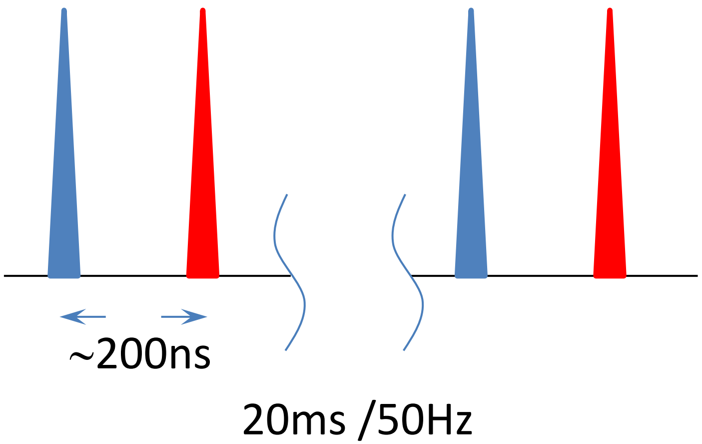
	Design number	*Achieved number at the moment*
Tunable Wavelength：	50 – 180 nm	148nm-88nm,
Pulse Energy：	>100 uJ (1 mJ)	210 uJ
Pulse length：	100 fs /1 ps	~1ps
Bandwidth：	Fourier transform limit	<0.05%(HGHG)
Jitter：	<30 fs	Not measured
Rep Rate：	50 Hz	20Hz

Poster number: MOP002

DCLS upgrade : 2nd FEL line



- 2nd FEL line is planed for installation in the middle of 2018.
- The property of new line, e.g., polarization, pulse duration, bandwidth, wavelength range, is still open to discuss.
- EPU is chosen at this stage



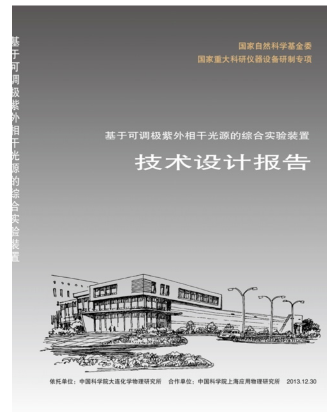
Time structure of double pulse e beam

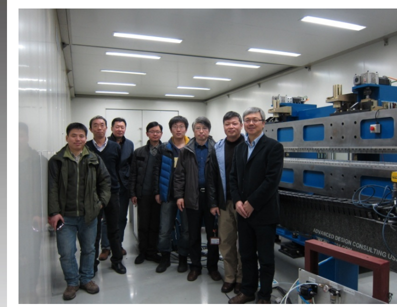
Idea from SwissFEL

Milestone

2012.03 Starting of DCLS

2013.08 Review of TDR of DCLS



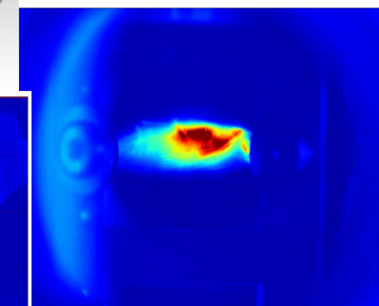


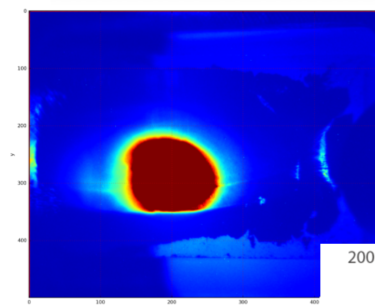
2013.12 Prototype of Undulator

2014.10 Starting of Construction

2016.04 LINAC installation

2016.09 Undulator spontaneous emission



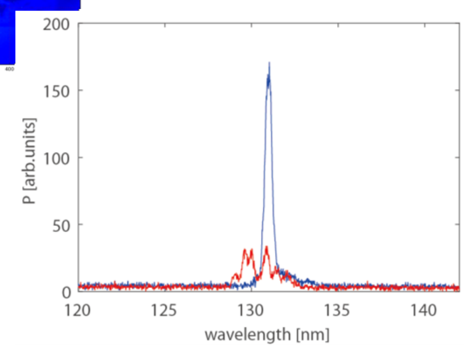


2016.11 FEL SASE lasing

2016.12 FEL HGHG lasing

2017.06 First user experiment

2017.08 Tunable wavelength



2018.07 2nd FEL line installation

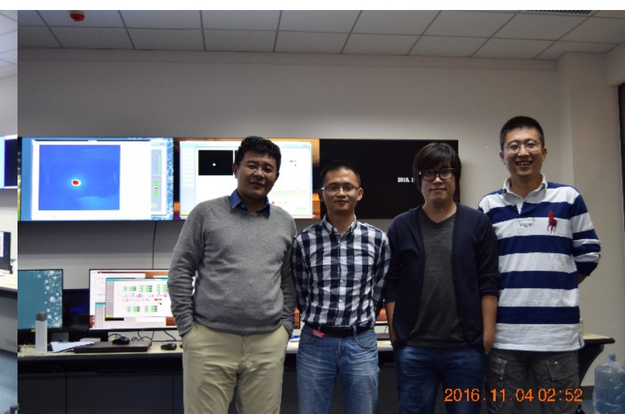
2012.05 First time to DCLS location

2013.08 Review of DCLS TDR

2014.11- 2016.01 DCLS Building construction

2016.05 Linac Installation

2016.09 e Beam getting through



2016.11 First SASE lasing

Acknowledgement

BNL: Prof. Lihua Yu

SLAC: Prof. Alexander Wu Chao

Prof. Zhirong Huang

Dr. Feng Zhou

Dr. Alan Fry

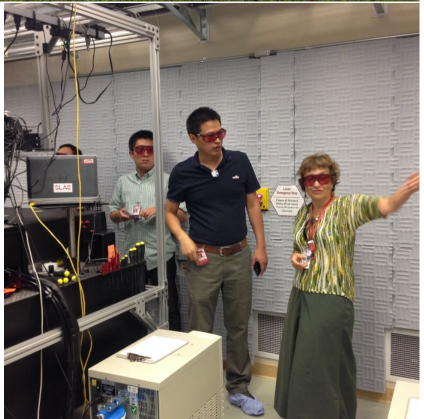
Dr. Sasha Gilevich, etc.

FERMI: Dr. Marco Zangrando

Dr. Miltcho Danailov

DCLS team:
Dalian institute of Chemical Physics, CAS
Shanghai Institute of Applied Physics, CAS

Photocathode gun:
Prof. Chuanxiang Tang' group, Tsinghua University



Thank you for attention

Supports from NSFC and CAS are gratefully acknowledged !