Commissioning and first lasing of FELiChEM: a new IR and THz FEL oscillator in China

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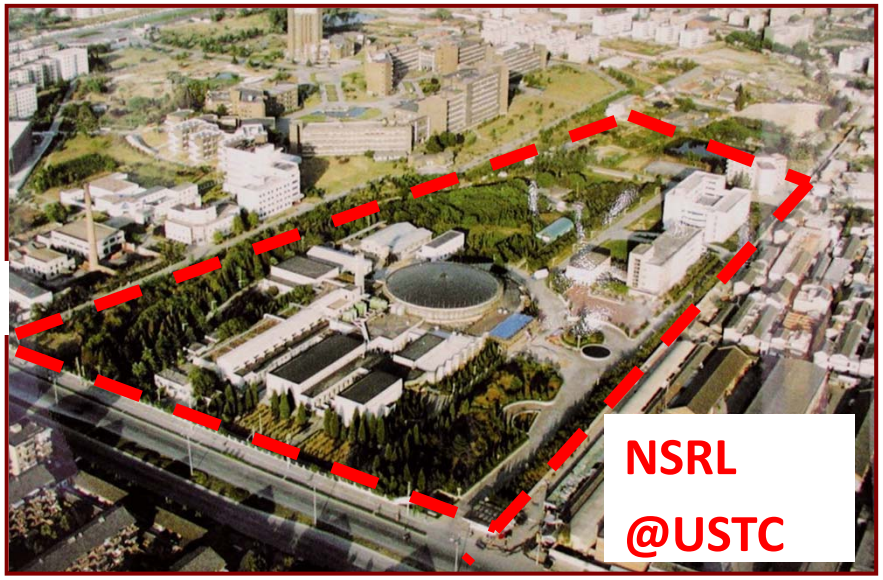
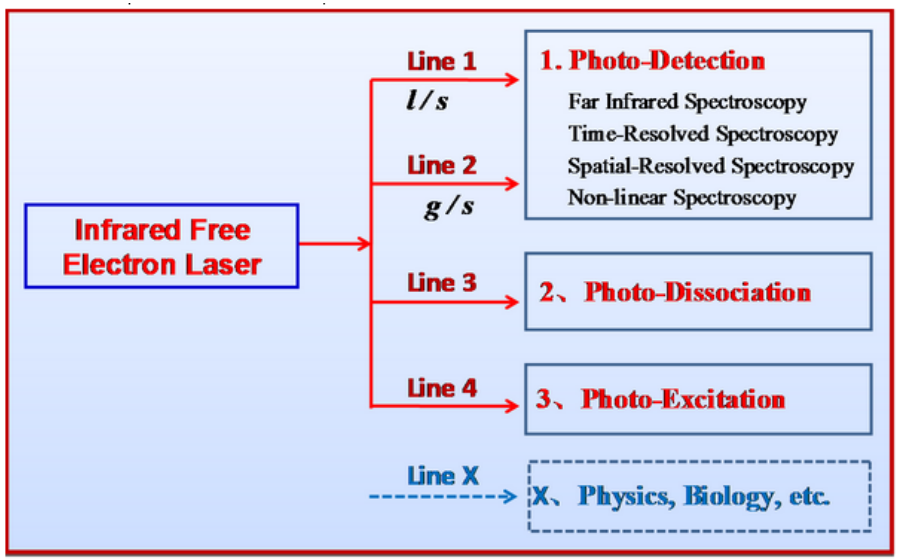
National Synchrotron Radiation Laboratory

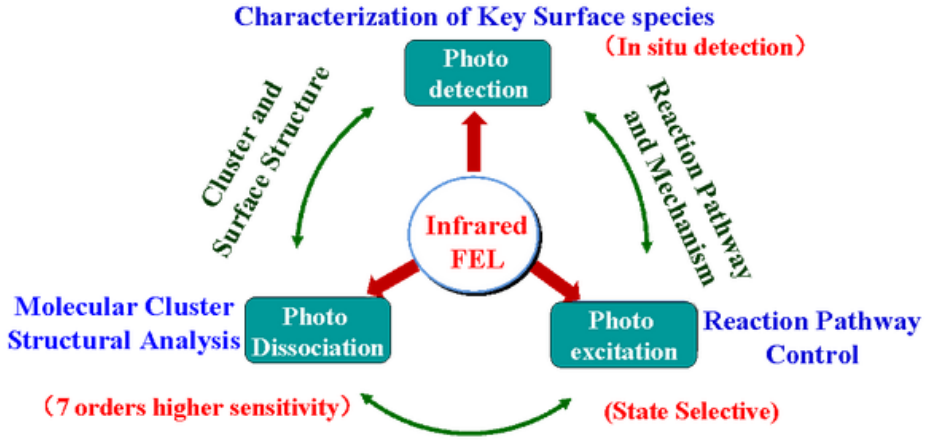


Introduction of FELiChEM

基于可调谐红外激光的能源化学研究大型实验装置
Tunable Infrared Laser for Fundamentals of Energy Chemistry

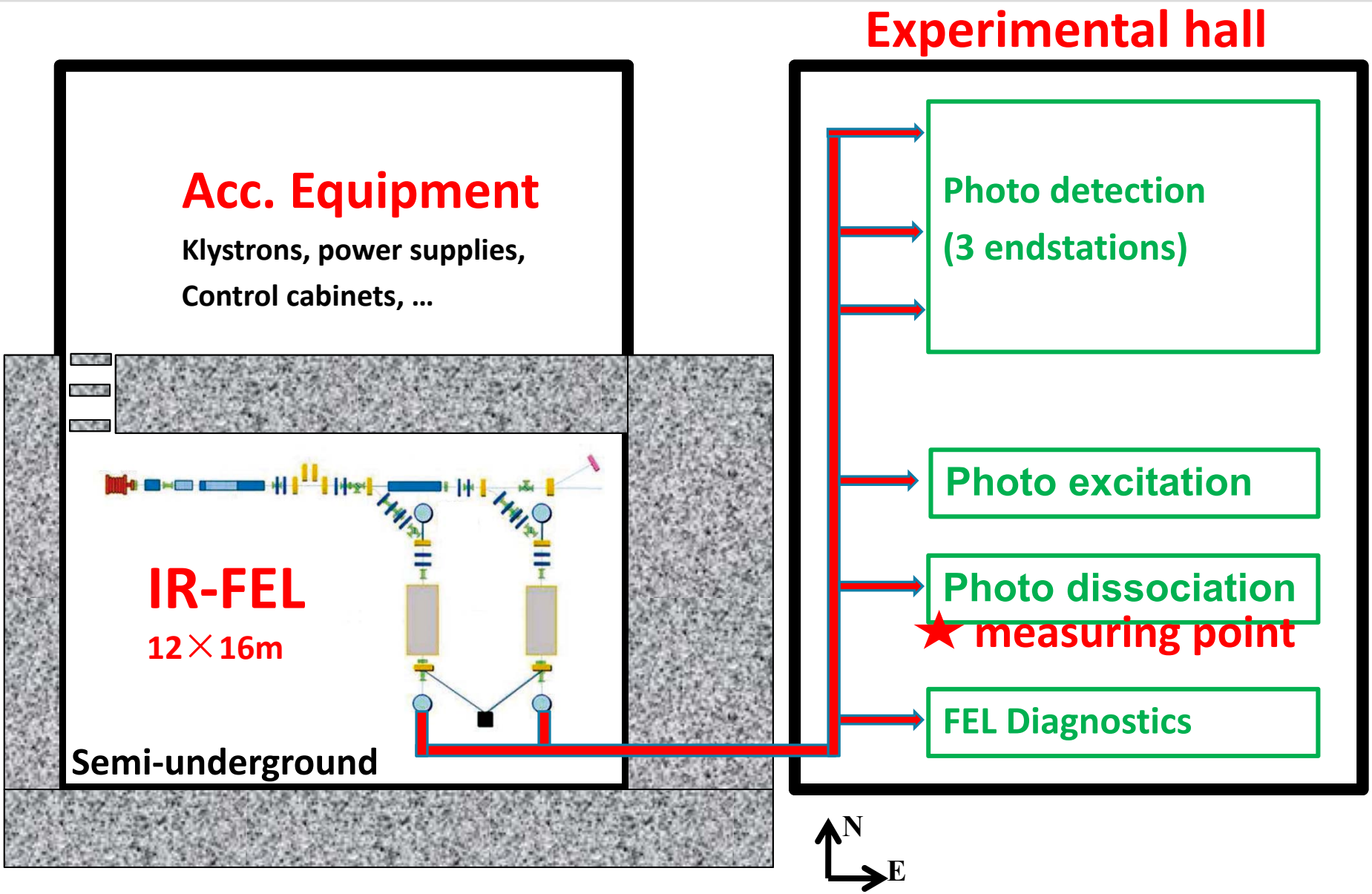
- **Funded by National Natural Science Foundation of China (NSFC) from 2015**
- **A dedicated light source aiming at energy chemistry**
- **Consisting of 1 IR-FEL, and 3 research stations: photo-detection, photo-dissociation, and photo-excitation.**





http://www.felichem.ac

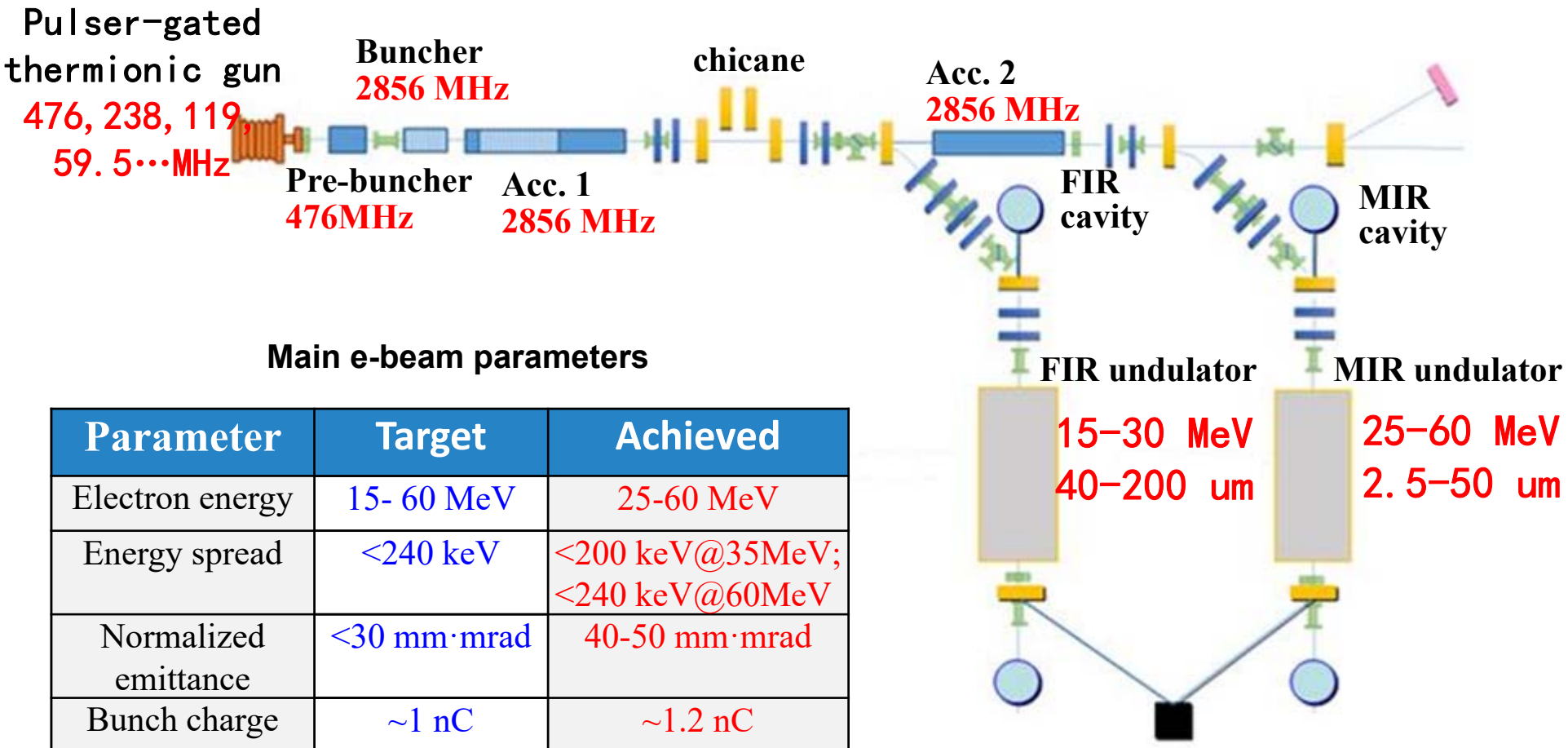
Schematic layout



Main FEL parameters

Laser Type	2 Oscillators
Wavelength Range	2.5-50 μm, 40-200 μm
Monochromacity	0.3~3%
Polarization	Horizontal
Pulse Structure	Macropulse + micropulse
Macropulse	**Repetition rate:** 10/20 Hz **Width:** 5-10 μs **Peak Power:** ~5 kW **(Pulse Energy: ~100 mJ)**
Micropulse	**Repetition rate:** 476, 238, 119, 59.5 MHz optional **Width:** 1-5 ps **Peak Power:** ~5 MW **(Pulse Energy: ~50 μJ)**

Accelerator

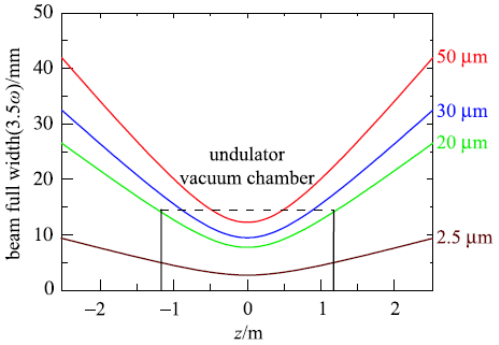


Main e-beam parameters

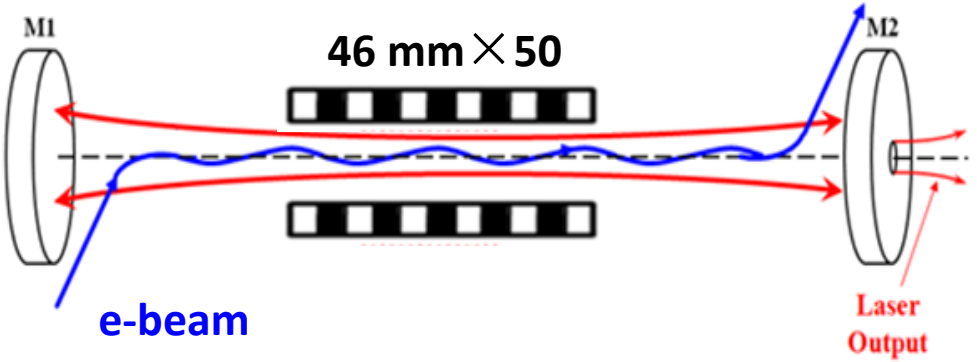
Parameter	Target	Achieved
Electron energy	15- 60 MeV	25-60 MeV
Energy spread	<240 keV	<200 keV@35MeV; <240 keV@60MeV
Normalized emittance	<30 mm·mrad	40-50 mm·mrad
Bunch charge	~1 nC	~1.2 nC
RMS bunch length	1-5 ps	~4.5 ps (w/o chicane)

FEL oscillators

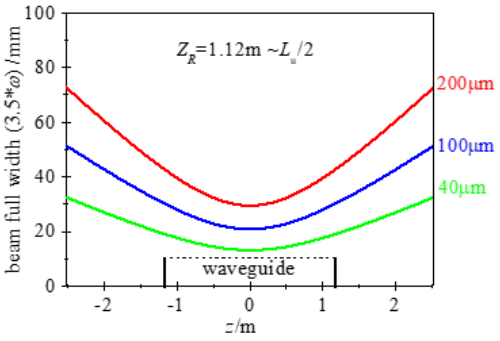
MIR oscillator

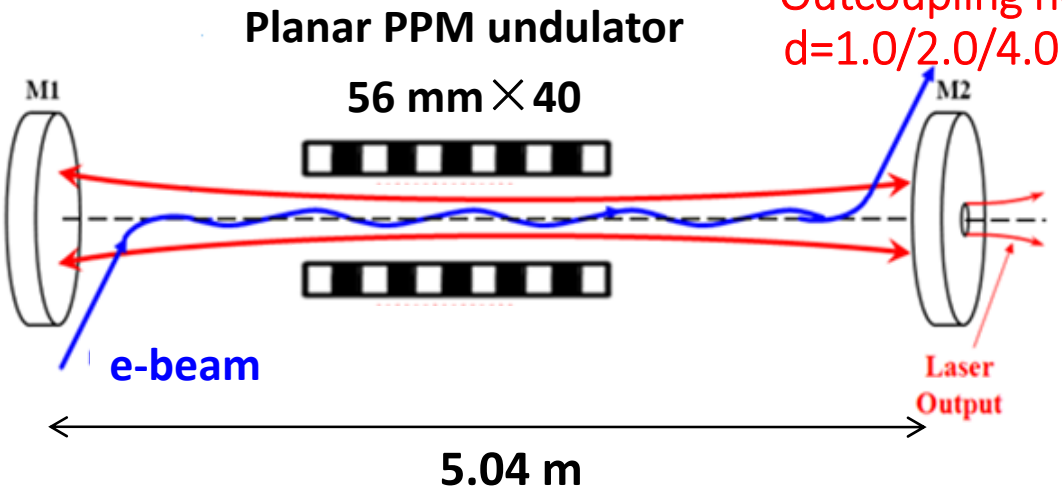


Outcoupling holes:
d=1.0/1.5/2.5/3.5 mm



FIR oscillator



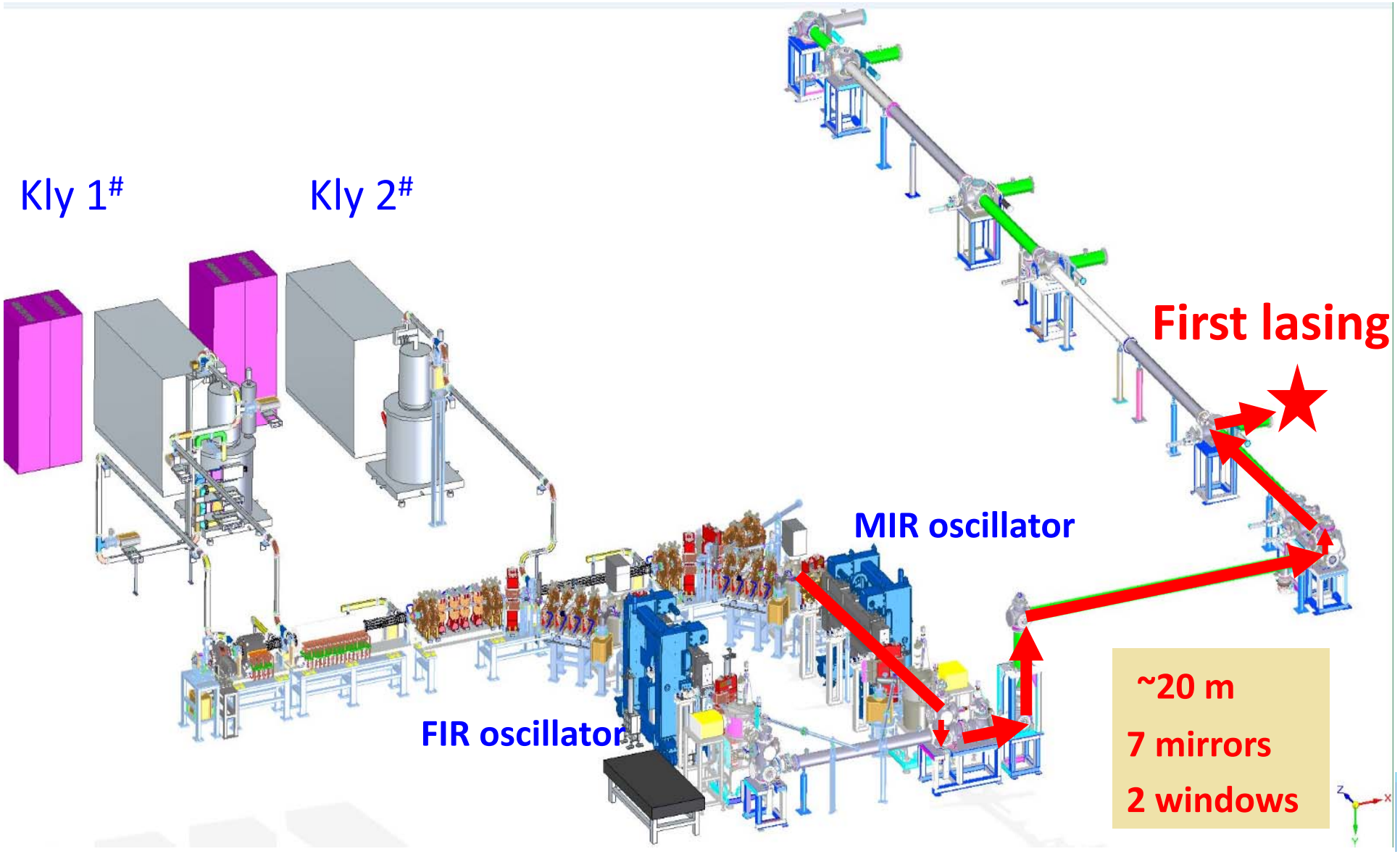


Commissioning status

※ **We experienced two stage commissioning**

- **1st stage: Jul. 24 – Sep. 27, 2018**
  - **DC beam** from the e-gun (without grid pulser)
  - Heavy beam load and large space radiation dose inside the tunnel
  - Failing in detecting the IR undulator spontaneous radiation inside the tunnel due to the strong jamming
- **2nd stage: May. 24 – Jul. 22, 2019**
  - **Pulsed beam** from the e-gun (238/119/59.5/29.75 MHz)
  - Detecting the IR radiation in the experimental hall
  - **Success in observing the spontaneous radiation and the lasing signal in the first day of the FEL commissioning (9 June)**
  - Shutdown on 22 Jul. to replace some components for improving the e-beam quality

FEL commissioning in 2nd stage

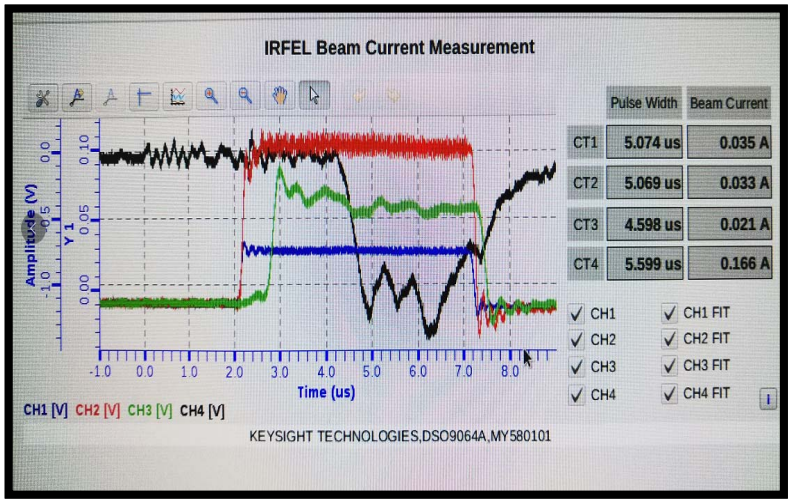


First lasing

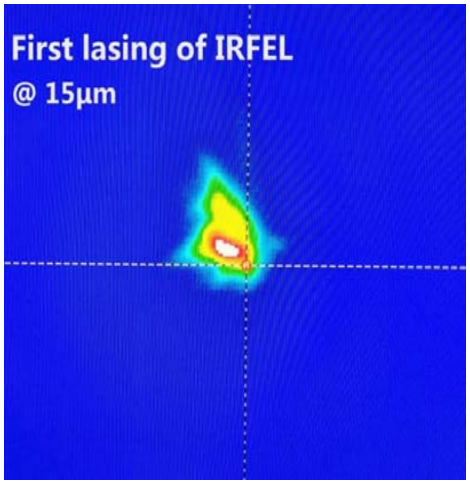
Undulator spontaneous radiation

- Detected by a liquid-nitrogen cooled MCT (HgCdTe) **@ 15 μm**
- measured: **38 μW @ Endstation-1**
  - 20 m away from undulator exit
  - Passing through 2 windows & reflected by 7 mirrors
- Calculated: 60-180 μW @ undulator exit

First lasing



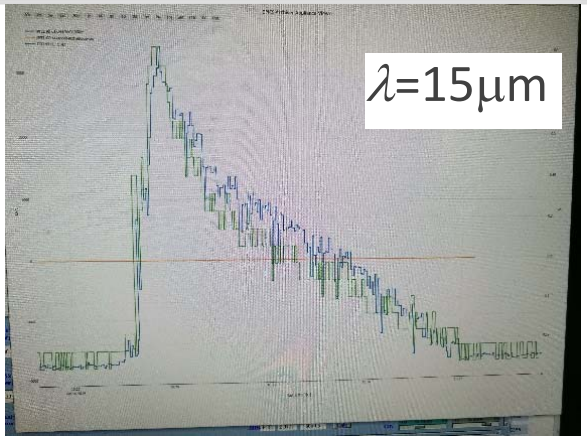
Black line: FEL signal from a pyroelectric probe

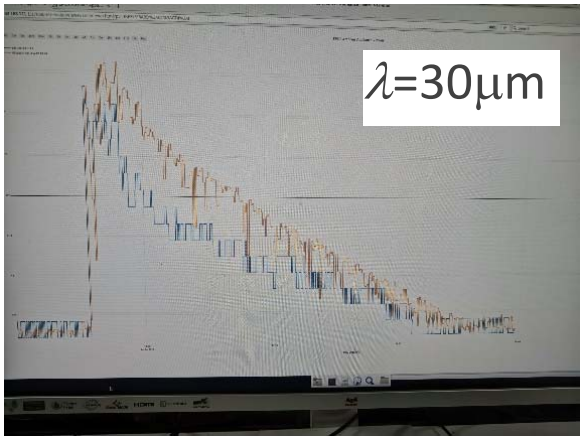


IR light spot @ Endstation-1

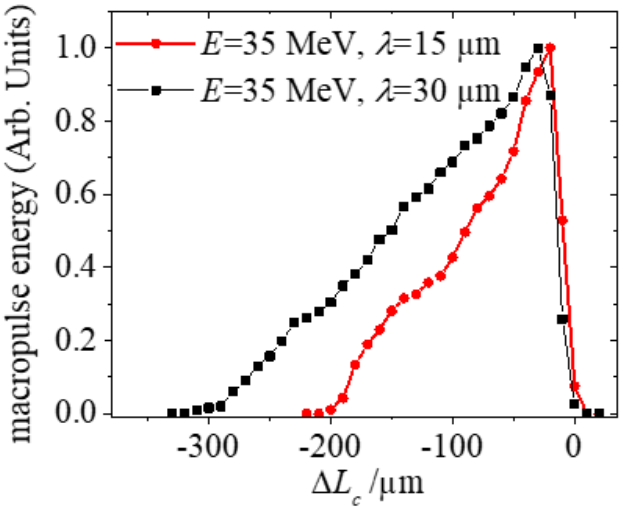
- **First lasing @ 15 μm**
- Detected at **Endstation-1** by a pyroelectric probe and a pyroelectric camera
- Max. **~27 μJ** /micropulse

Measured results



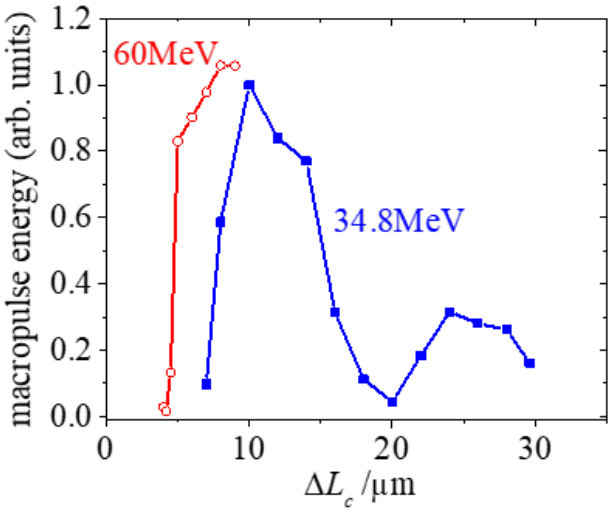


Detuning curve



Lasing was observed over a cavity length scan range of about 10 times of radiation wavelength.

Wavelength coverage



- 4-30 um.
- What happened to 20 um FEL? Absorption or power gap?
- It will be studied in next run.

Future plans

- **Measurement of the basic FEL**
  - Spectrum
  - spectral range
  - temporal structure
- **Increasing the electron beam current**
  - rep. rate of microbunch
  - rep. rate and pulse width of macrobunch
- **First user experiment with the mid-infrared FEL**
  - doing our best to make the MIR FEL stable
  - commissioning the FIR oscillator in timesharing mode

Thanks for your attention !