

Upgrade Project to Introduce a Photo-Injector into t-ACTS at RARiS, Tohoku University

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Introduction

- Motivation
- Goals



Laser system

- Yb fiber laser oscillator
- Pulse picker
- Multi-pass amplifier
- Fourth harmonic generator



Laser development status

- Measurement of laser spectrum
- Optimization of LN modulator
- Alignment of low-power laser
- Test of high-power laser

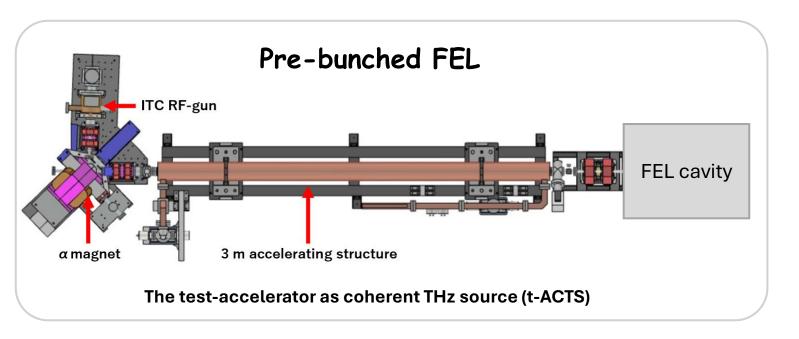


Conclusion and next steps



Extreme nonlinear interactions of THz radiation with matter are the next frontier in nonlinear optics. [1]

- Comparable to electric field between atoms in crystal lattice.
- Can cause magnetization reversal in metallic ferromagnets



Achievement of t-ACTS (thermionic cathode) [2]

< 100 fs @ 5 pC Electron bunch length



Goals (photocathode)

THz radiation

Electric field strength	100 MV/cm
Magnetic field strength	33 T

Electron beam

Electron bunch charge	> 20 pC ^[3]
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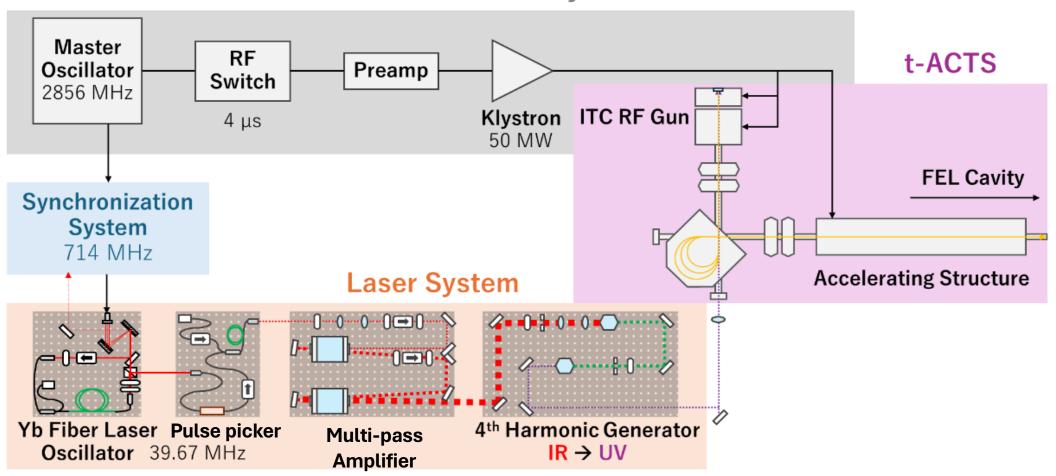
Laser	
Laser wavelength	262 nm (UV)
Laser wavelength (from oscillator)	1047 nm (IR)
Laser energy (UV)	> 2 µJ/pulse





Overall systems

RF System

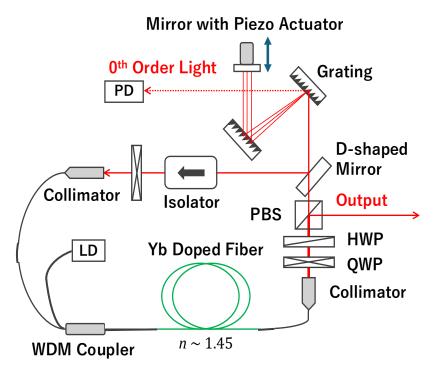


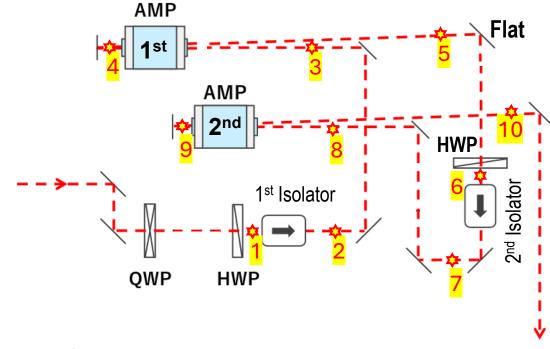


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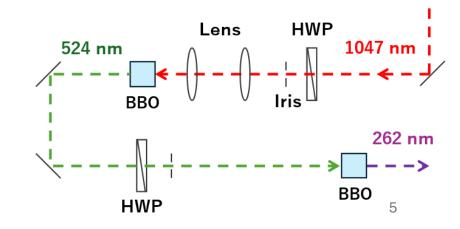
Multi-pass amplifier

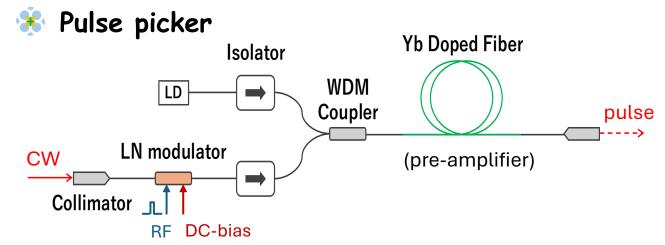
Yb fiber laser oscillator





Fourth harmonic generator

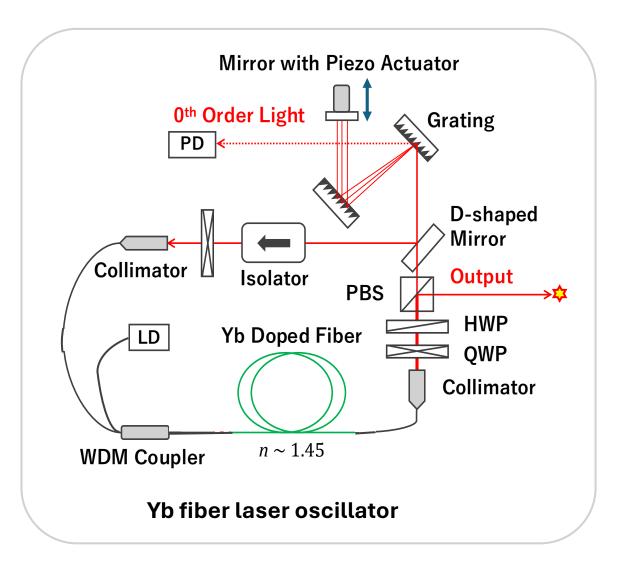




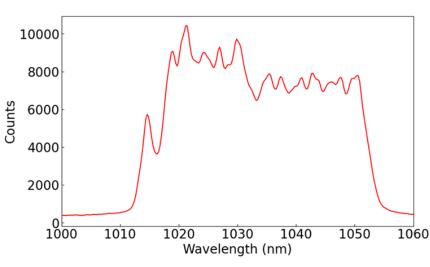


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Measurement of laser spectrum



Laser spectrum [4]



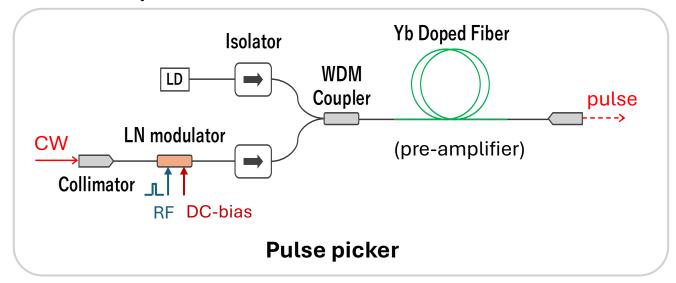
- Central wavelength of 1,037±1 nm (IR)
- Spectral width of 31±2 nm



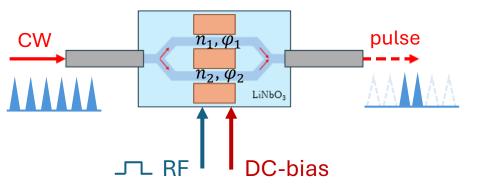
Laser development status

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Optimization of LN modulator



LN modulator



$$n \equiv \text{refractive index}$$

 $\Delta \varphi \equiv \text{phase difference } (\varphi_2 - \varphi_1)$

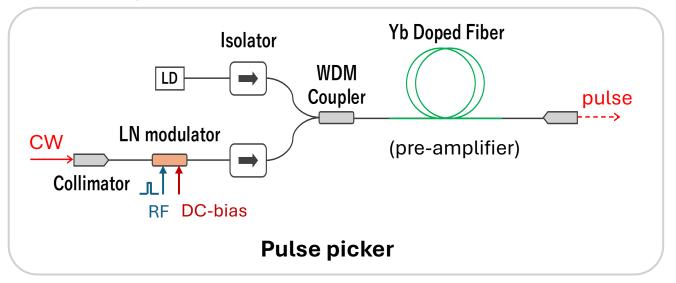
• RF = 0 V
$$\Delta \varphi = \pi$$
 $\Delta \varphi = \pi$

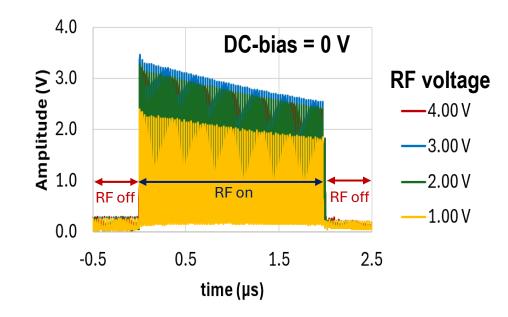
• RF
$$\neq$$
 0 V \longrightarrow $\Delta \varphi$ = 0

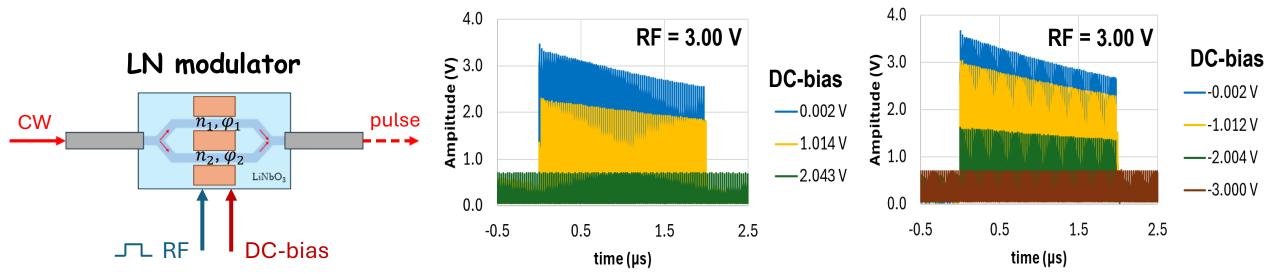


Laser development status

Optimization of LN modulator





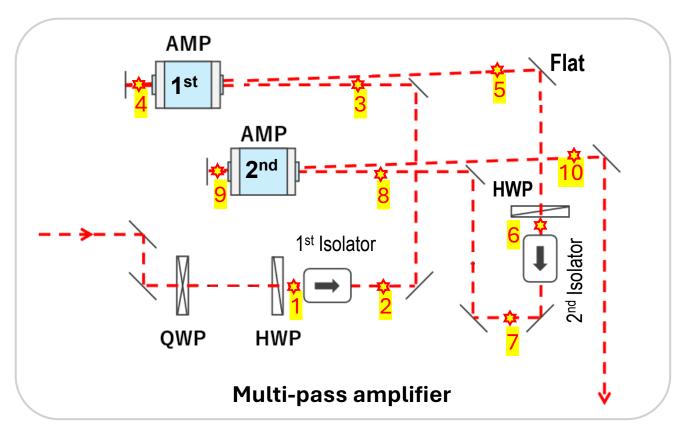




Laser development status

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Alignment of low-power laser



Measured laser power

Position	Average power (mW)	Transmission
1	2.10	
2	1.87	89%
3	1.87	
4	1.87	100%
5	1.72	92%
6	1.66	
7	1.37	83%
8*	0.92	
9*	0.92	100%
10*	0.87	95%

Test of high-power laser

- Leakage of pump pulse of the first amplifier
- Expand laser size of over 12.7 mm from 2 mm.
- Degrade laser characteristics and invalidate the alignment.



Conclusions



Yb fiber laser oscillator was successfully constructed and confirmed to generate an IR laser



LN modulator of pulse picker was optimized.



Alignment of the low-power laser was completed with at least 80% transmission for all elements



Alignment was invalidated when the high-power laser was operated due to leakage of pump pulse of the first amplifier.



Next steps



An iris will be used to filter out the pump pulse, allowing only the amplified IR pulsed laser to pass through and proceed to the fourth harmonic generator.



The fourth harmonic generator will be aligned and investigated to achieve the generation of UV laser.