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Present status of laser-produced plasma EUV light source

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1-Komatsu / EUVA (Extreme Ultraviolet Lithography System Development Association)
2- Gigaphoton / EUVA, 3- Gigaphoton Inc.

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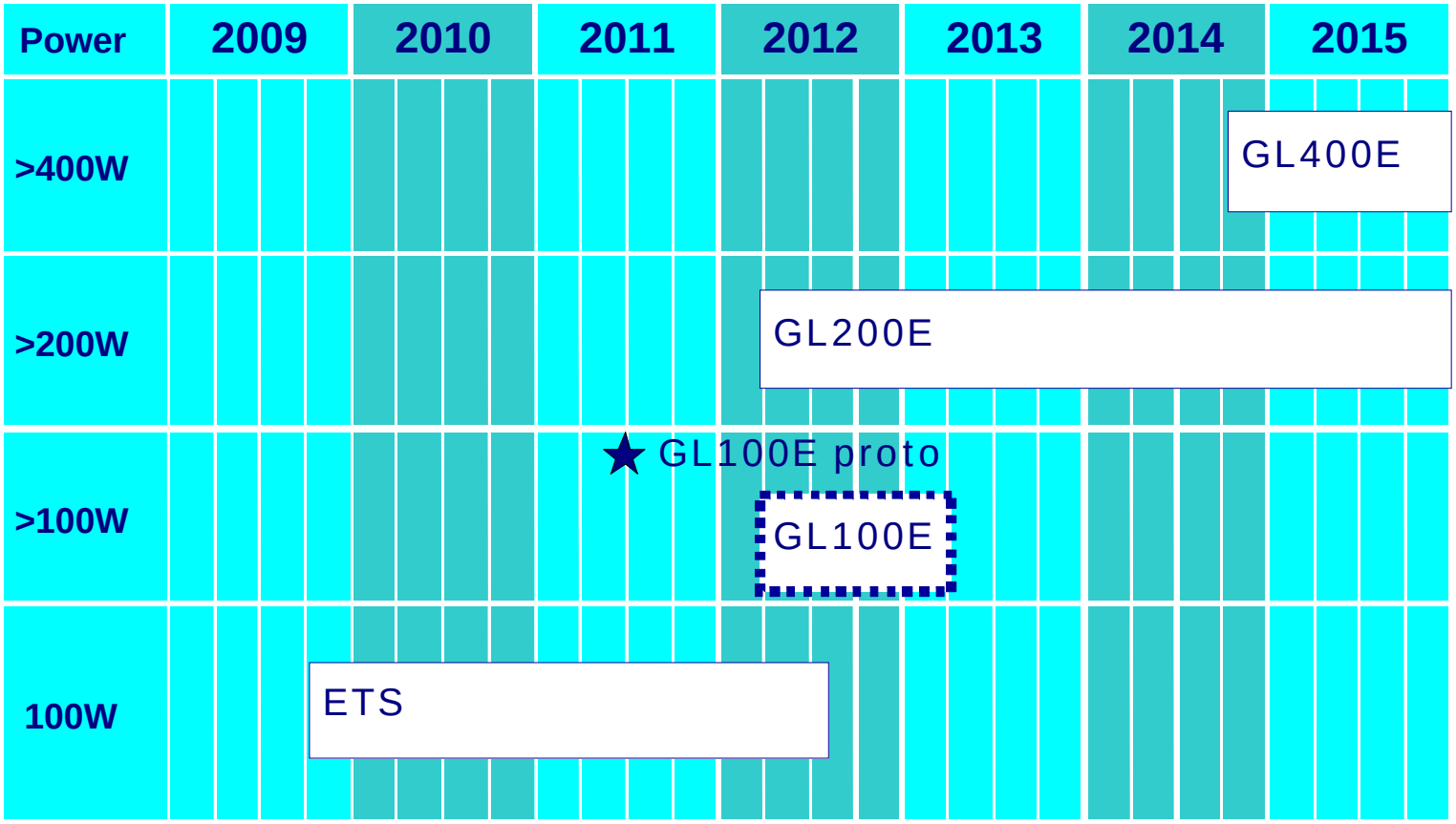
Summary

- Product roadmap
  - ✓ Target specification and schedule of Gigaphoton LPP source product is updated.
    - 75W average power will be available in 2011/2Q.

- ETS (1st generation integrated setup LPP source)
  - ✓ First performance data is reported.
    - Average power: 2.5W (@I/F, calculation)
    - Brightness: 25W (@I/F, calculation)
    - Duty cycle: 10%

EUV Light Source Roadmap



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EUV Light Source Major Specifications

EUV model		ETS	GL100E proto	GL200E	GL400E
Power	W	100	>100	>200	>400
Pulse energy	mJ	1	>1	>2	>4
Max rep rate	kHz	100	100	100	100
Max Duty Cycle	%	75	>75	>75	>75
Sub systems					
Target Material and Shape		Sn droplet	Sn droplet	Sn droplet	Sn droplet
Droplet Diameter	micro meter	60	10	10	10
Debris Mitigation		Magnet and cleaning	Magnet and cleaning	Magnet and cleaning	Magnet and cleaning
Collector Mirror Lifetime	Bpls	11	>200	>1250	>1250
Tool Interface		No	Yes	Yes	Yes

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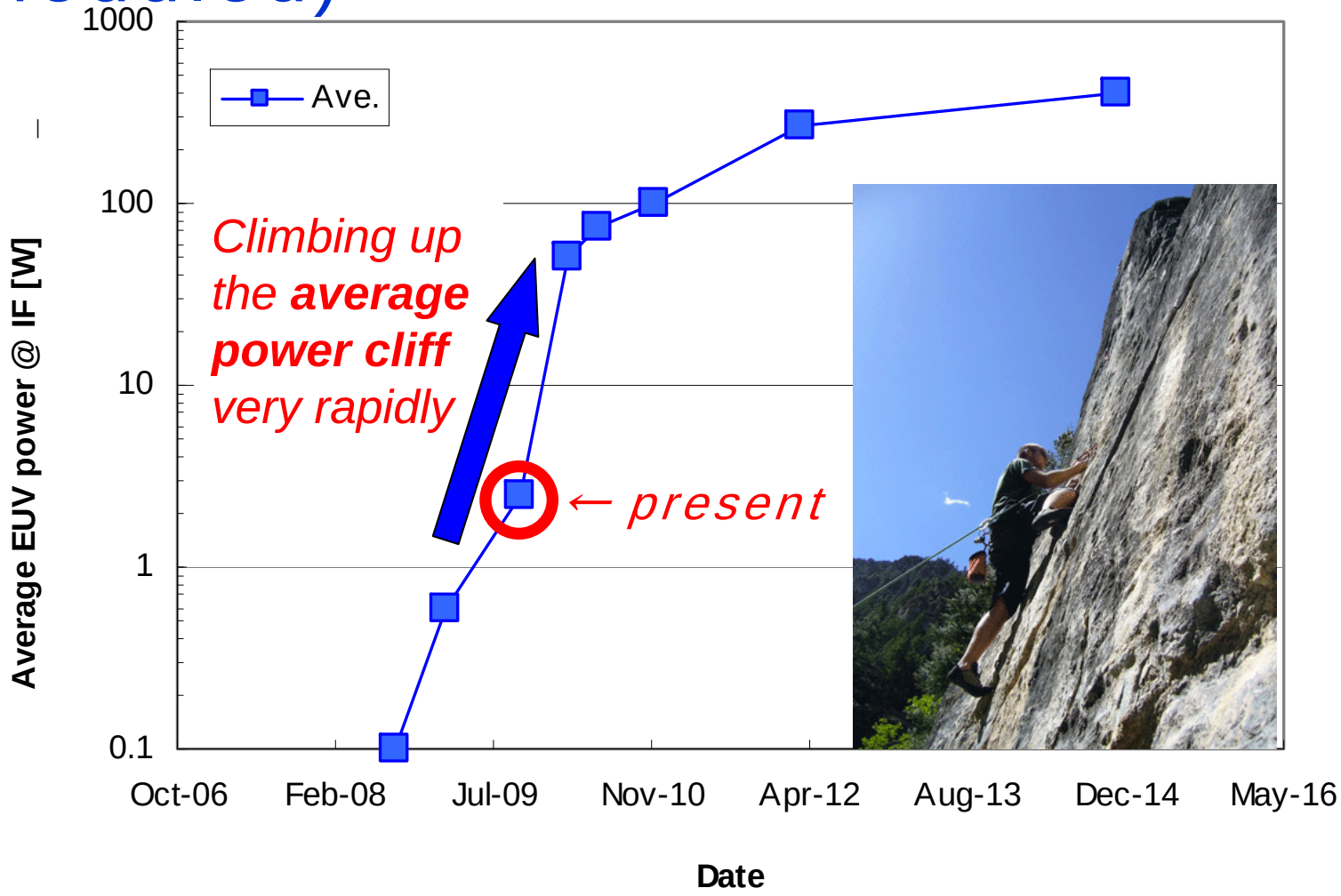
Average Power Improvement Chart (scheduled)



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Concept of Gigaphoton LPP Source

➢Requirement for EUV source for HVM

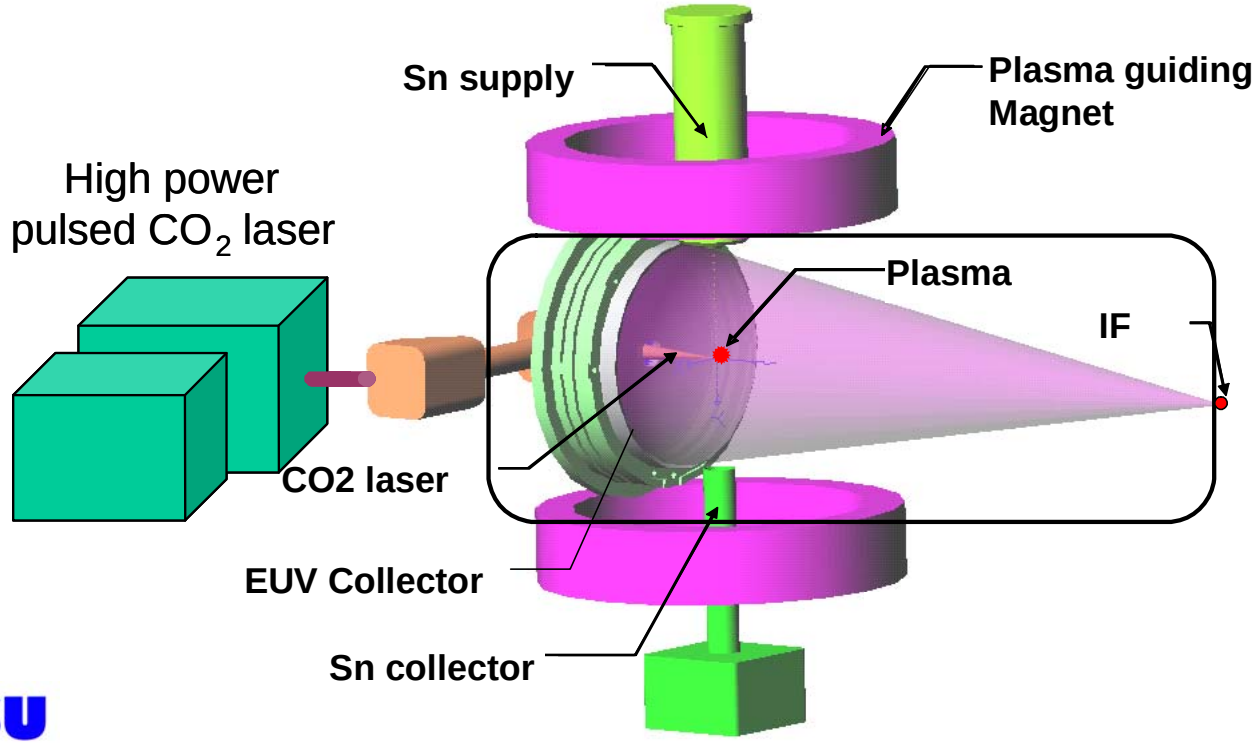
- High EUV power >115 W
- EUV Stability
- Collector mirror lifetime
- Low CoG / CoO

Original technologies

① CO_2 laser and Sn LPP source

② Magnetic field plasma guiding

③ High power pulsed CO2 laser



ETS System Configuration

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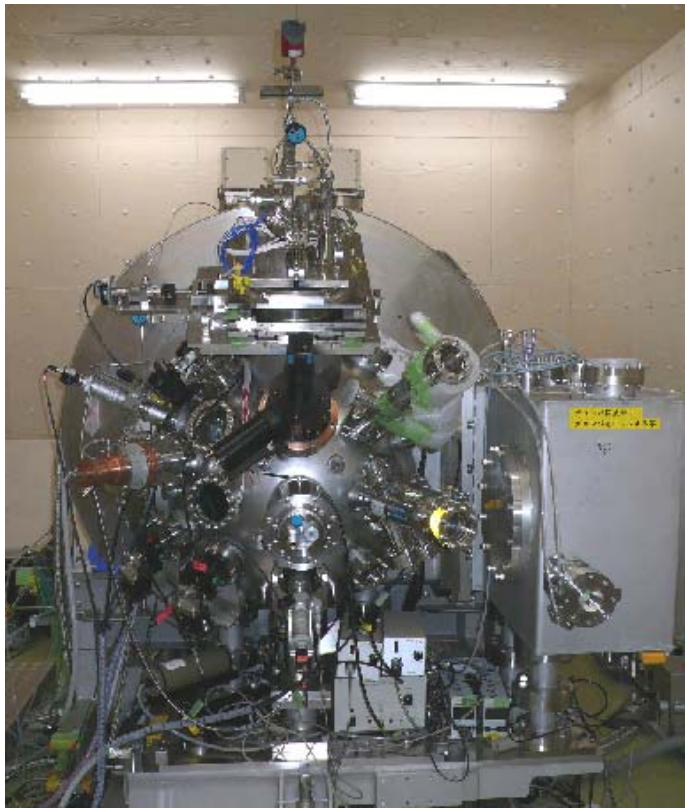
System layout

■ Laser System

Laser Power: 13 kW
Pulse Width: 20 ns
Repetition Rate: 100 kHz
Pulse energy stability : 2% (3s, 500 pulses)

■ EUV chamber



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ETS EUV Chamber Configuration

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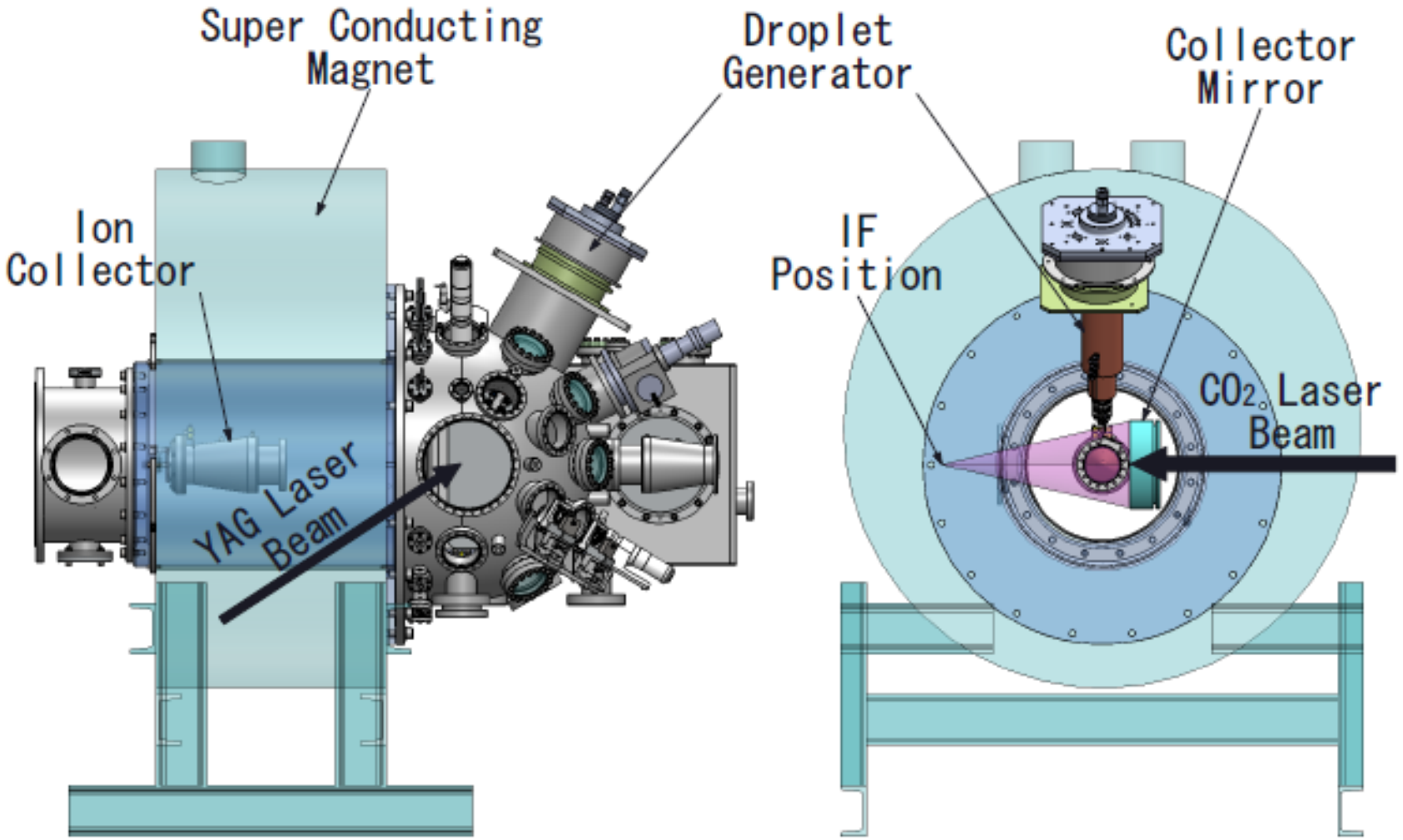

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Droplet Generator

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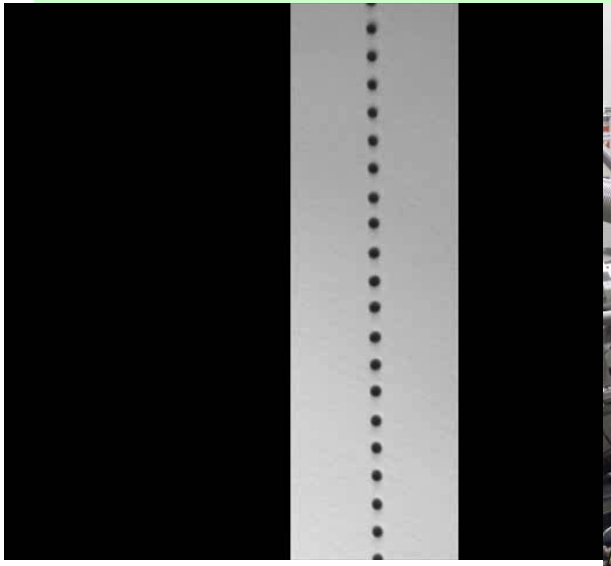
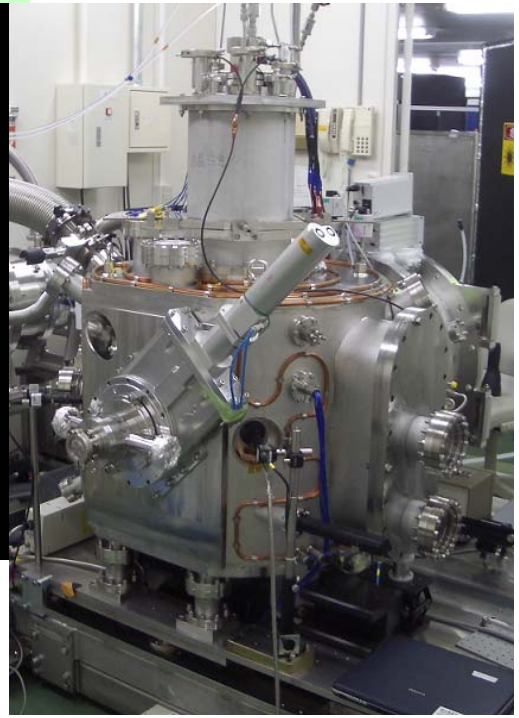
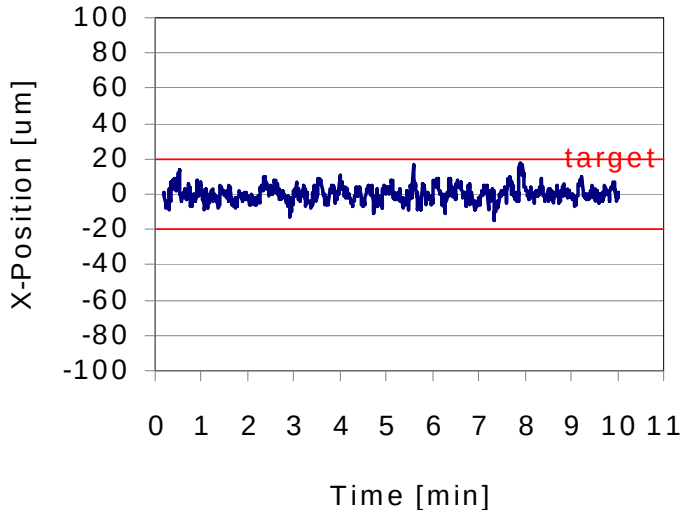
Droplet for ETS

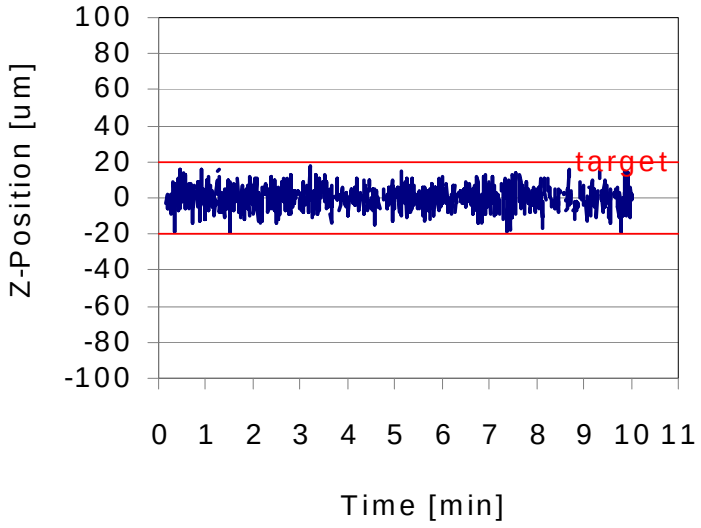
Diameter:	60um
Stability :	±13um
Velocity:	60msss/s
Frequency:	400kHz





Droplet experimental chamber





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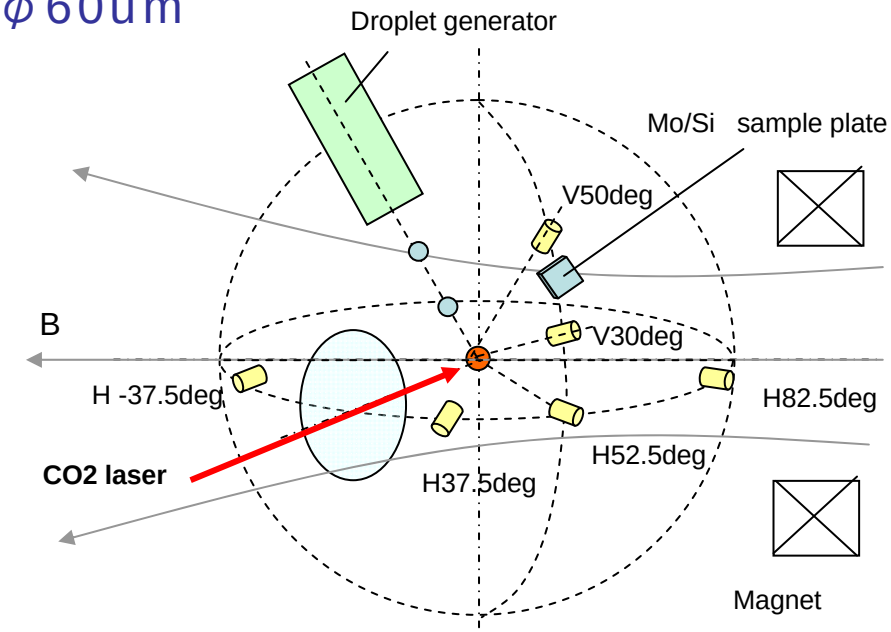
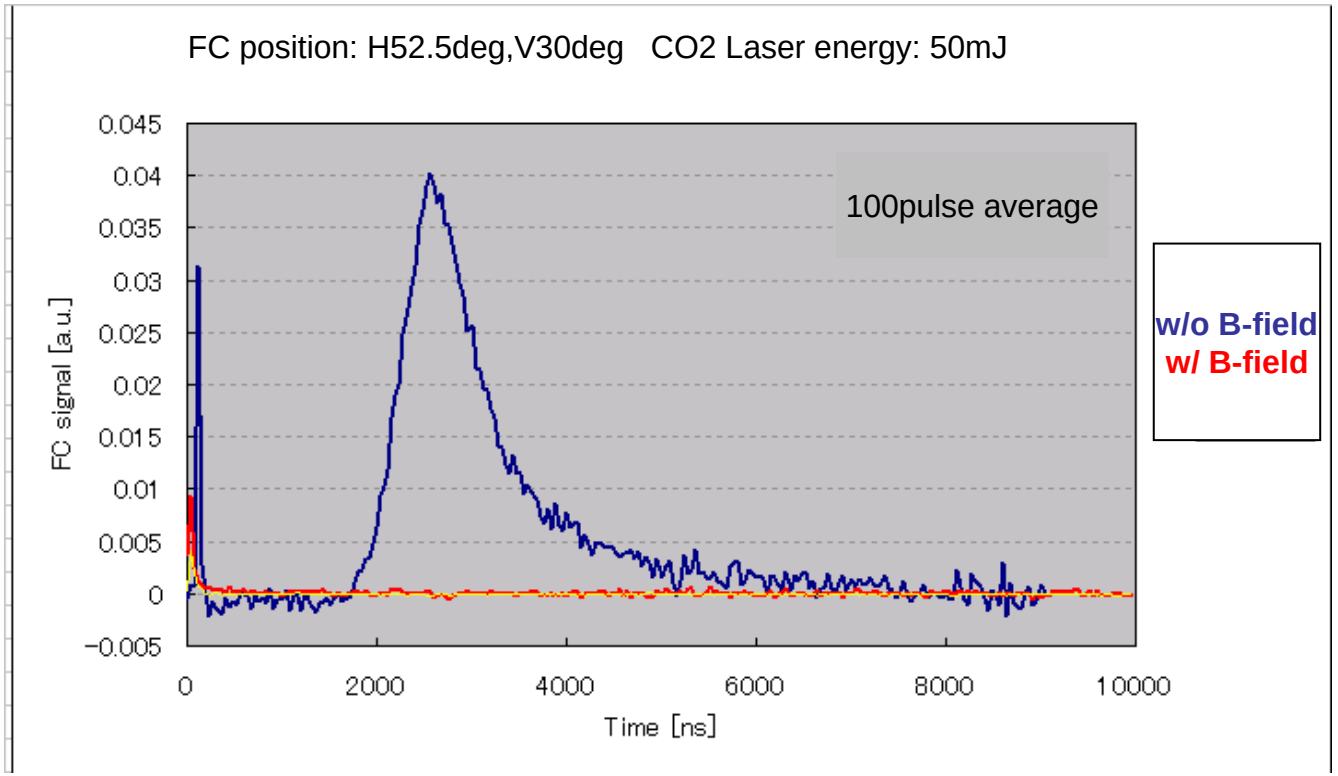
Mitigation Experiment

- Ion
  - ✓ Faraday cup: 1000pls(10ms)@100kHz
- Mirror life:Mo/Si
  - ✓ sample mirror: surface measurement
- Condition
  - ✓ Magnetic field applied
  - ✓ Laser; 50mJ, 100kHz, 2.4%duty(25ms on+1s off)
  - ✓ Droplet; ϕ60um



Ion Shielding by Magnetic Field – Faraday Cup signal

- Under application of Magnetic field, off-axis (related to B-field) ion signal is below the detection limit.



ETS Experiment

- 1st generation integrated LPP system
- Demonstration of 100W (av.75W) operation
  - ✓ Prove system concept with real data with integrated system
    - Pre-pulse target heating
    - Mass limited target
    - Magnetic mitigation
    - Mirror cleaning
- Clarify the engineering issues of component and find solution
  - ✓ CO2 laser
  - ✓ EUV chamber (mirror, droplet gen., etc.)
- Feedback engineering data to GL100E

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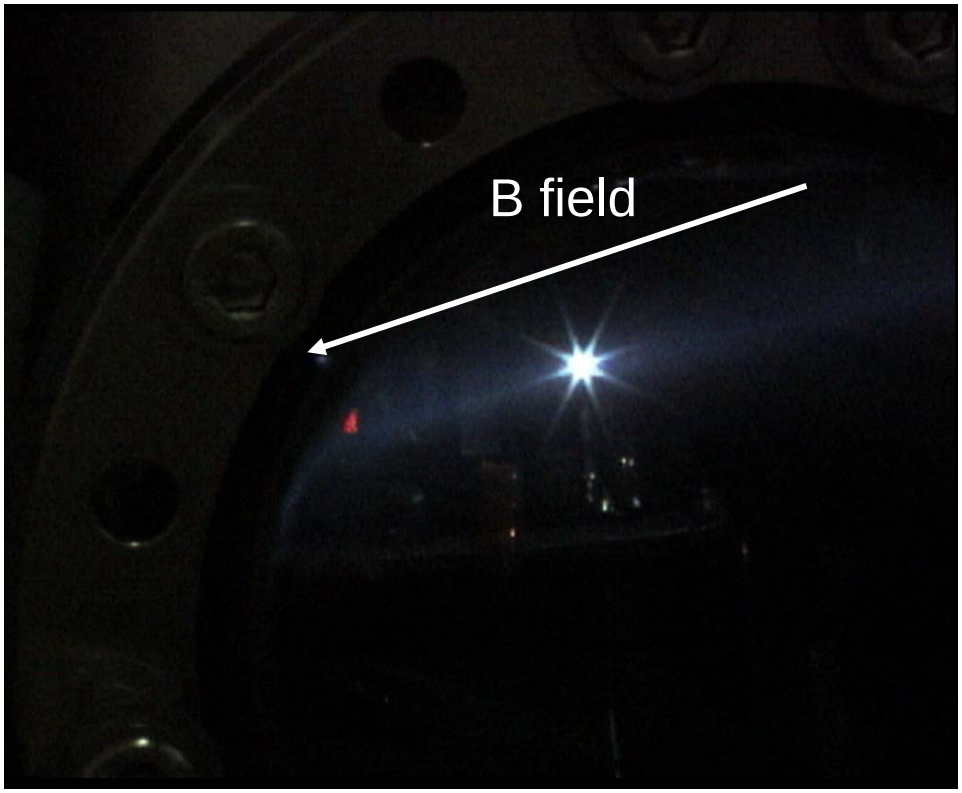
EUV Plasma Light



- ✓CO_2 Laser power 5kW
- ✓Duty 10%
  - Burst ON 20msec
  - Burst OFF 180msec

- ✓w/ Droplet position control
- ✓w/o Droplet timing control
- ✓w/o Energy control

EUV Energy w/o pre-pulse

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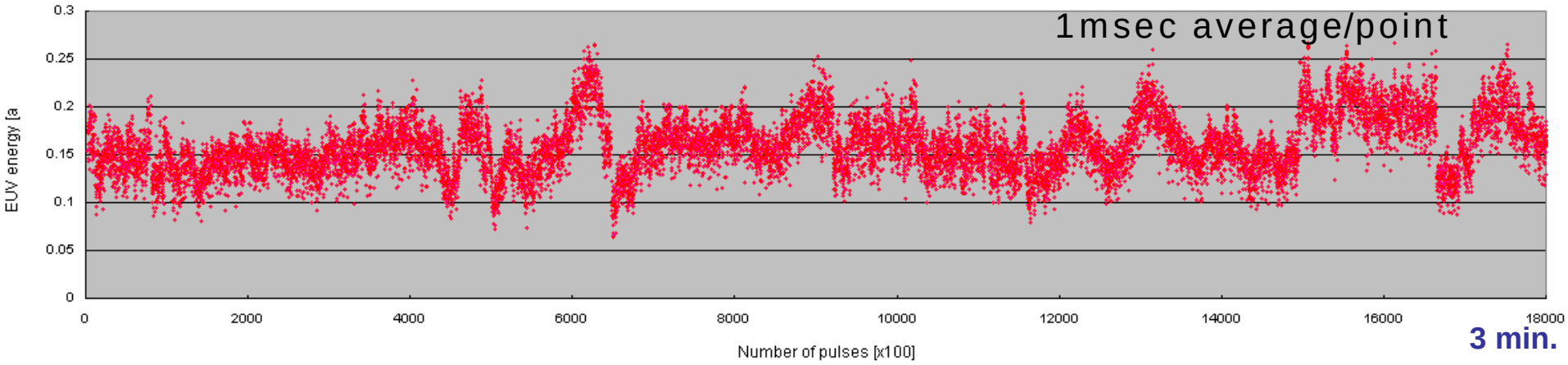

3 min.

- ✓w/ Droplet position control
- ✓w/o Droplet timing control
- ✓w/o Energy control

Average power (@I/F, calculation)	**2.5W**
Brightness (@I/F , calculation)	**25W**
Duty cycle	**10%**
Max. non stop operation time	**3 hr**
Experiment time	**10 hr**
Average CE	**1.5%**

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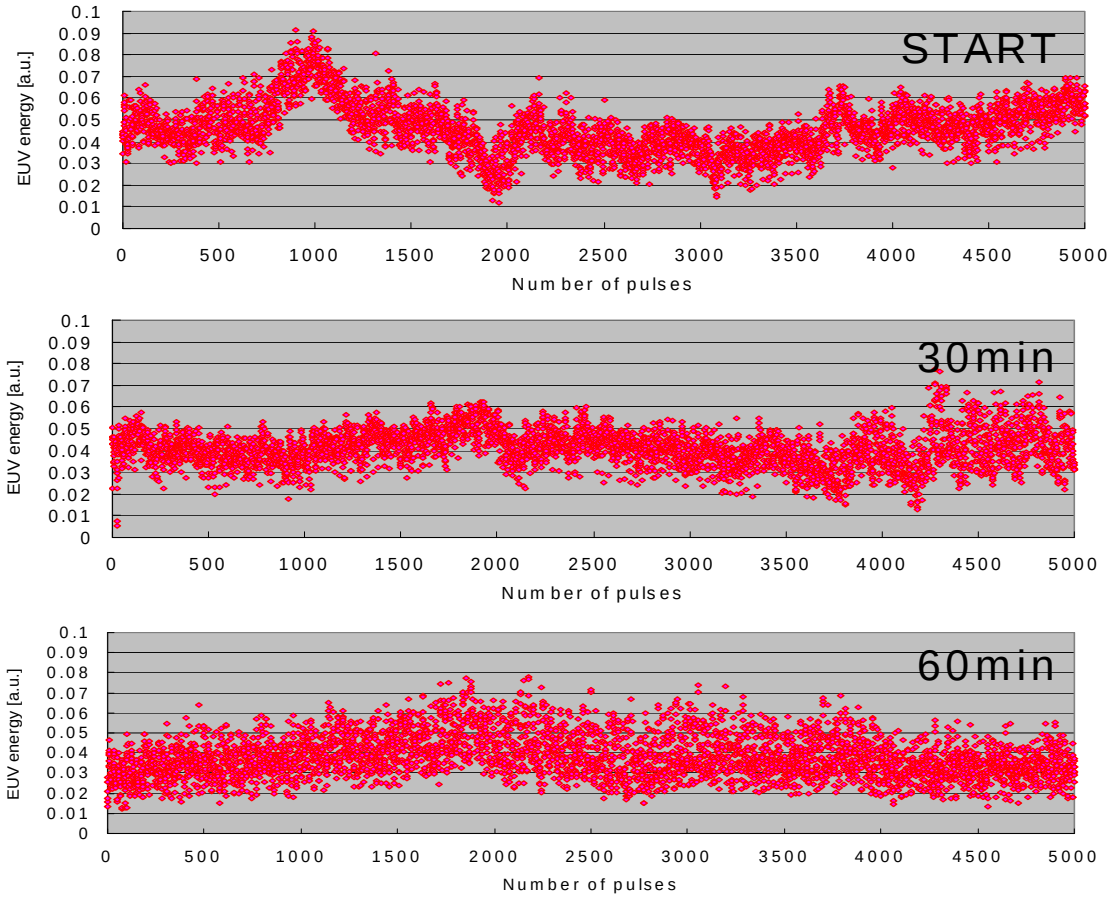
EUV Energy w/o pre-pulse

- Long term operation

✓w/ Droplet position control
✓w/o Droplet timing control
✓w/o Energy control



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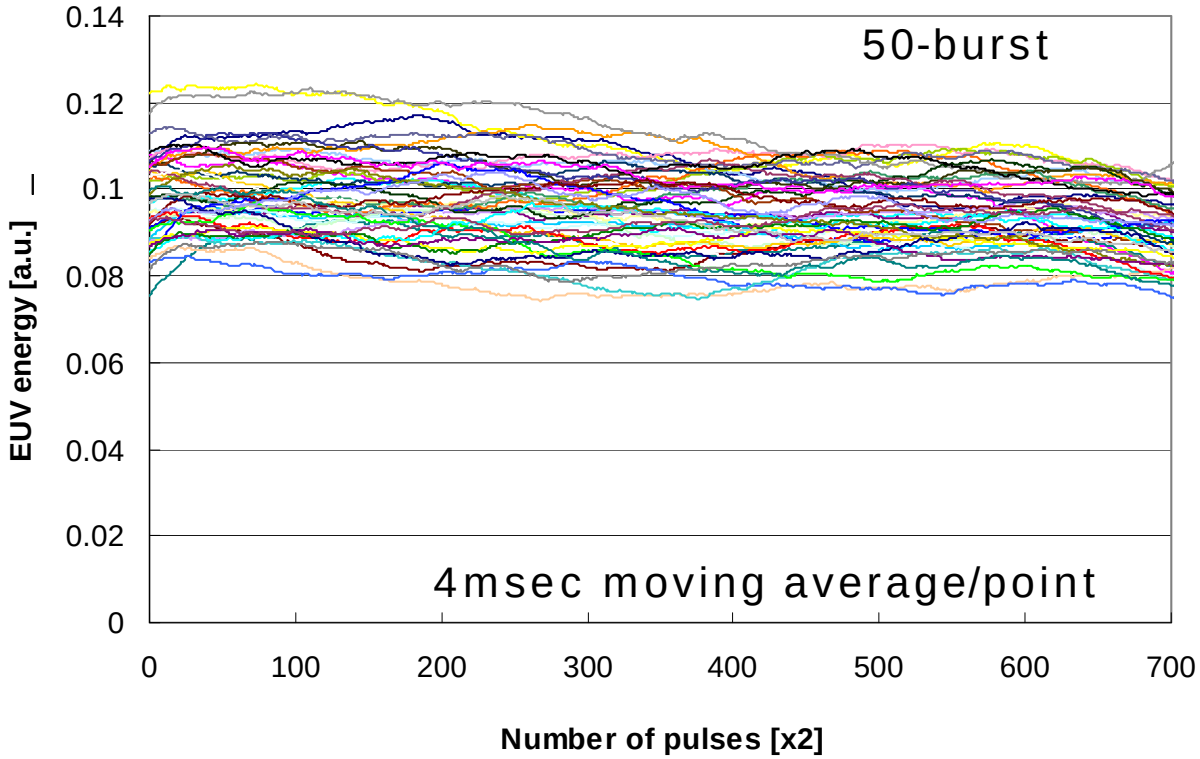
EUV Energy w/o pre-pulse

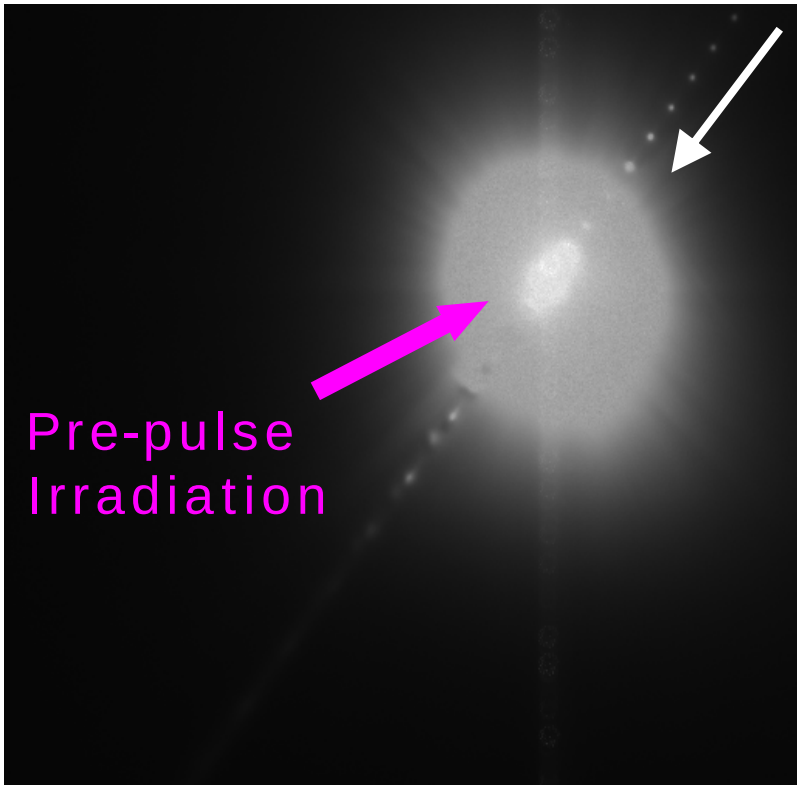
➢Burst mode stability



✓w/ Droplet position control
✓w/o Droplet timing control
✓w/o Energy control

System Status

- YAG laser is being prepared.
- 3% of CE with pre-pulse is expected.



Status Summary of ETS Experiment

General Information		Performance at Plasma		Integrated Performance			Performance Projections	
Supplier	**Type**	**Demonstrated operating time**	**Average EUV power in 2π at plasma (measured)**	**Level of integration**	**Demonstrated operating time**	**Average EUV power at IF**	**Projected average EUV power at IF by mid-year 2010**	**Projected average EUV power at IF by year-end 2010**
Gigaphoton Komatsu EUVA	Sn LPP	**3 hours @ 10% duty cycle**	**7.5W @ 10% duty cycle**	With droplets No integrated Source	**3 hours @ 10% duty cycle**	**2.6 W (calculated)**	75 W (Burst 100W @ 75% duty cycle)	100 W (Burst 100W @ 100% duty cycle)

Acknowledgments

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