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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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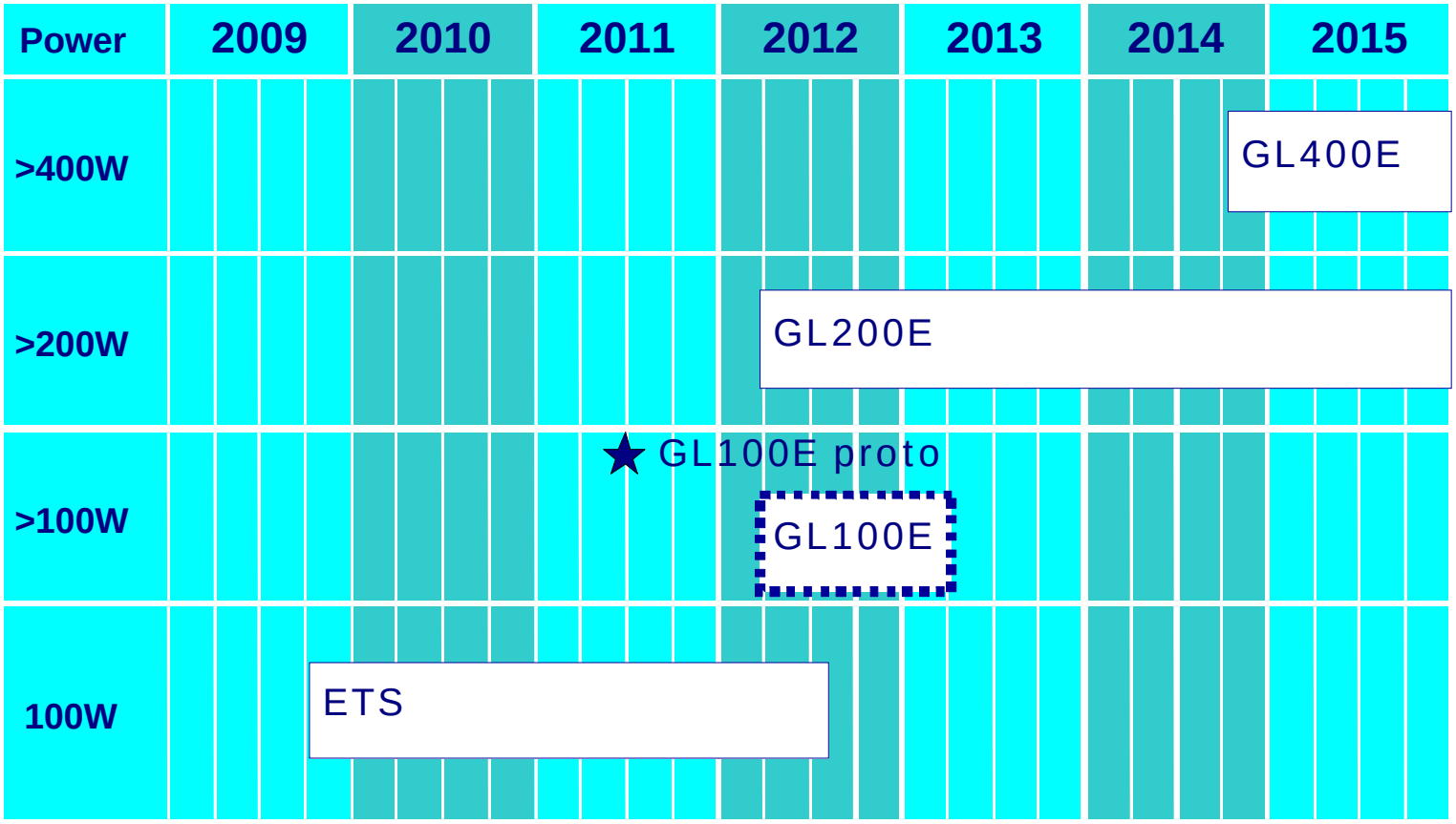
# Summary

- 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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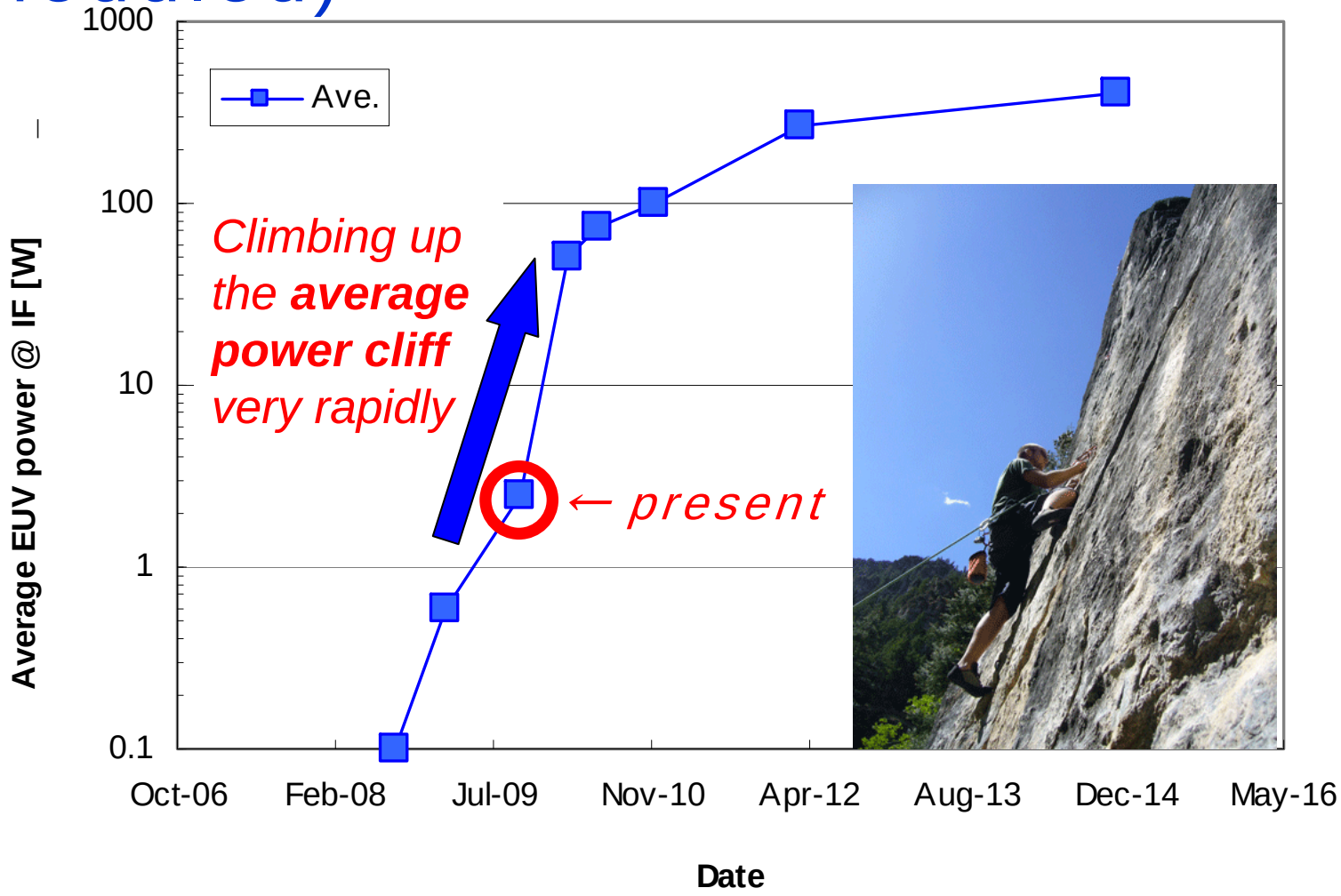
# Average Power Improvement Chart (scheduled)

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# Concept of Gigaphoton LPP Source

➢Requirement for EUV source for HVM

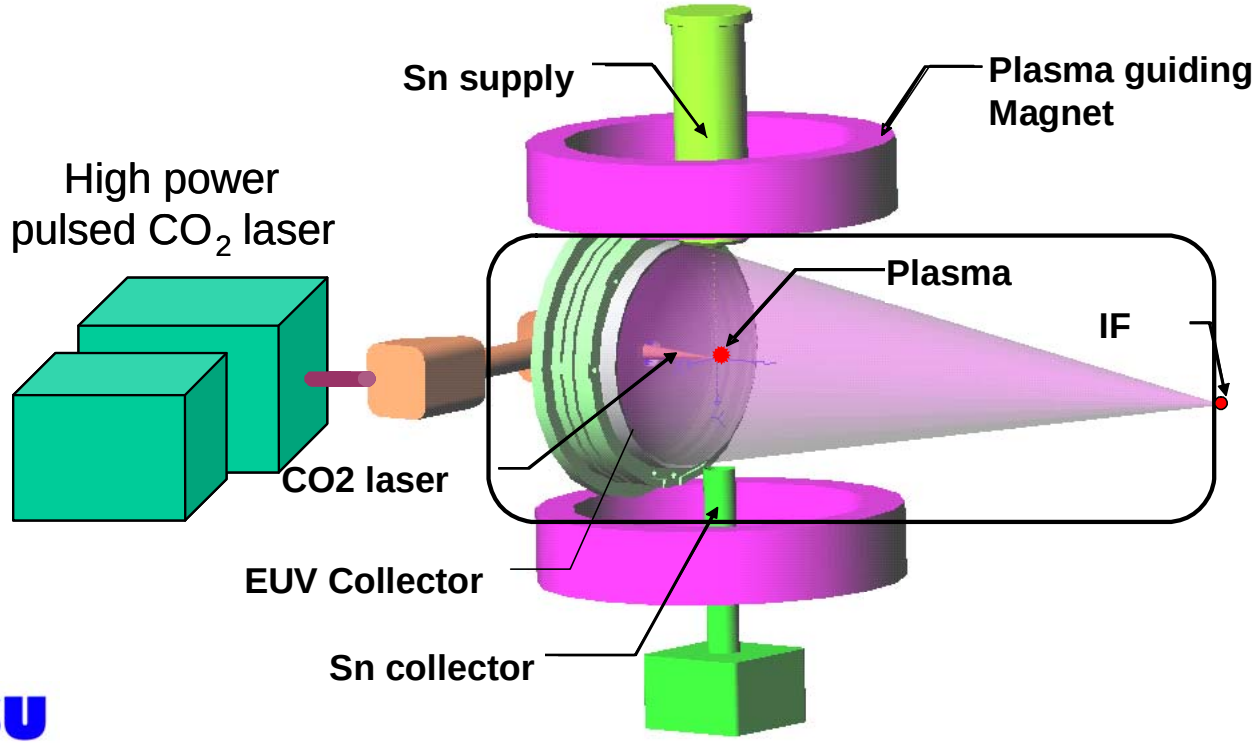
- High EUV power >115 W
- EUV Stability
- Collector mirror lifetime
- Low CoG / CoO

Original technologies

① $CO_2$ laser and Sn LPP source

② Magnetic field plasma guiding

③ High power pulsed CO2 laser



# ETS System Configuration

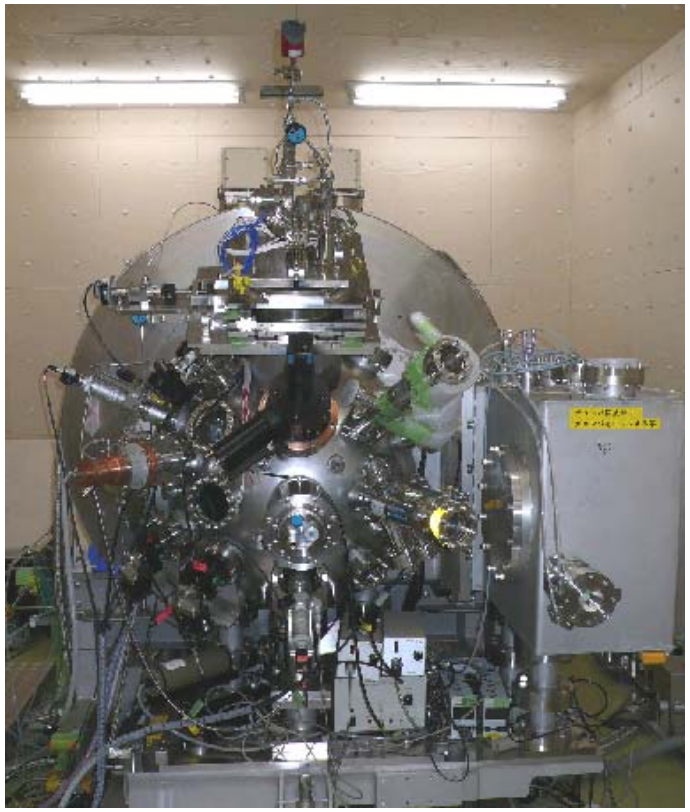
IRAI

## 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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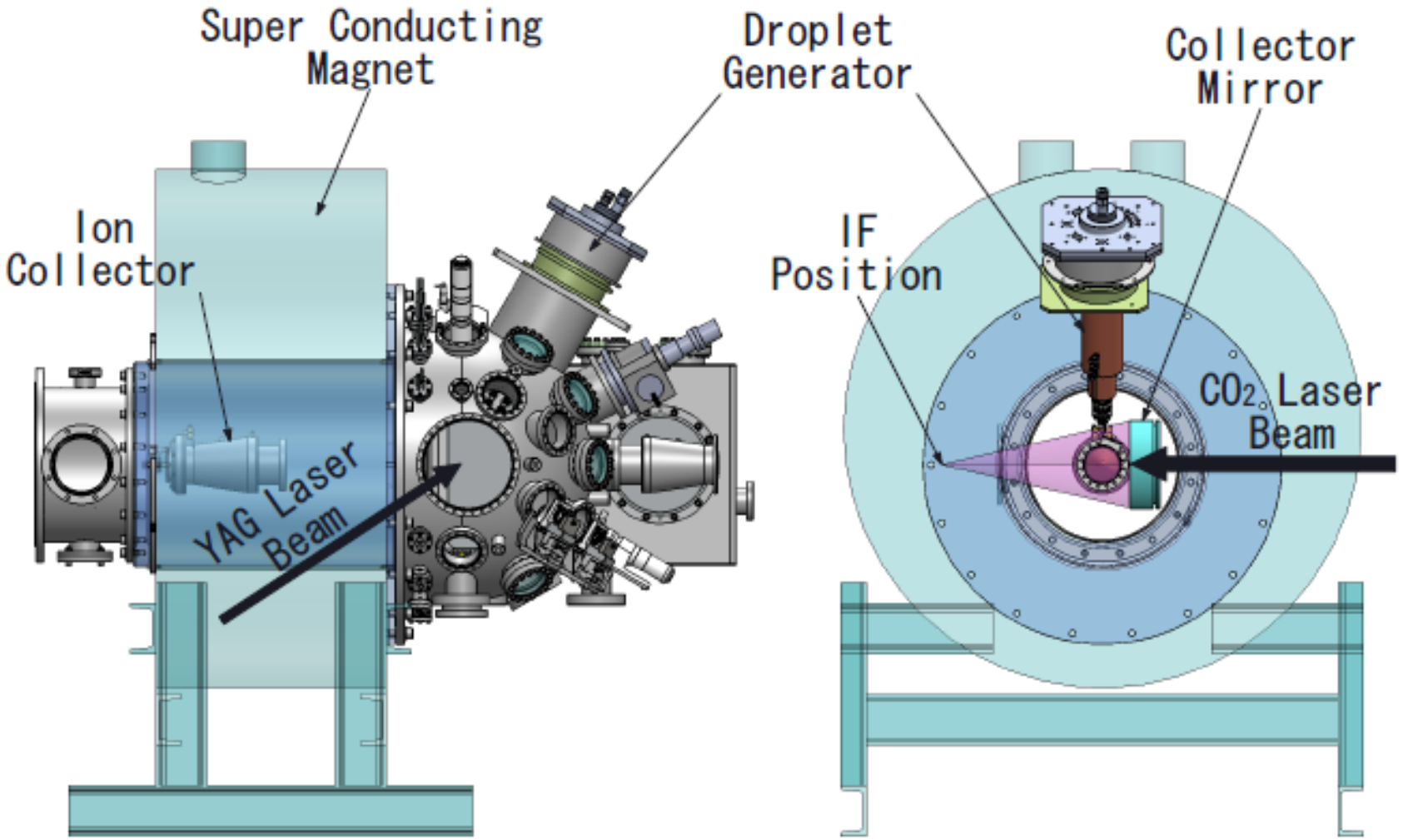


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# Droplet Generator

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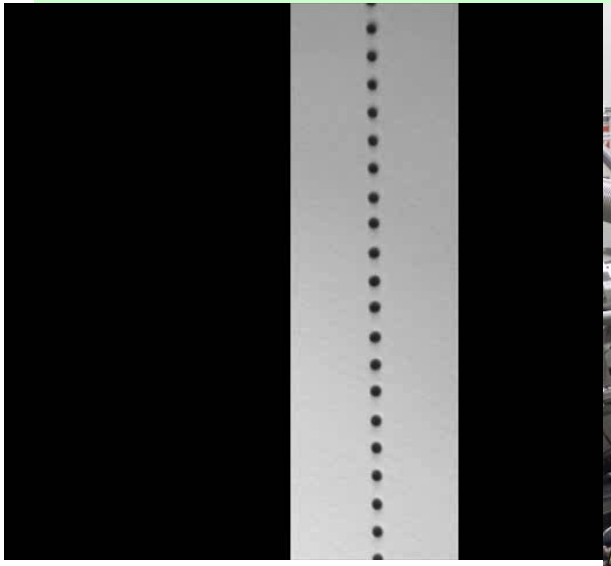
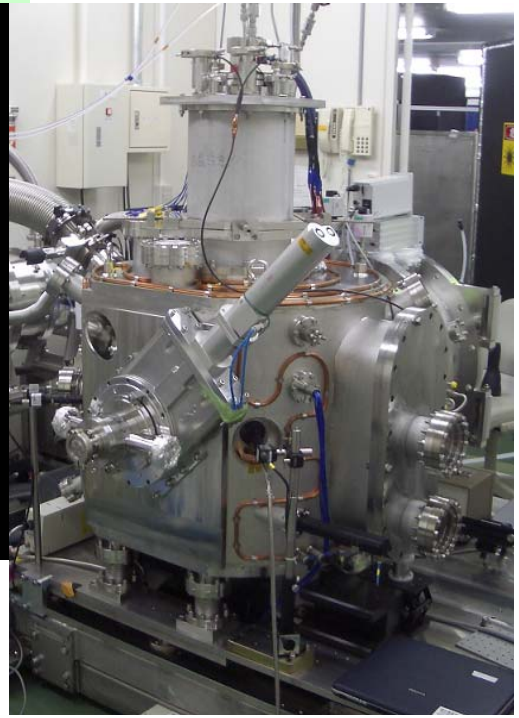
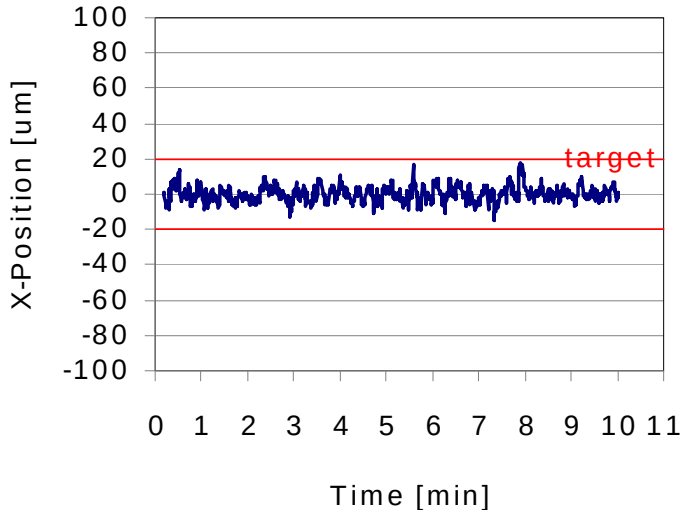
Droplet for ETS

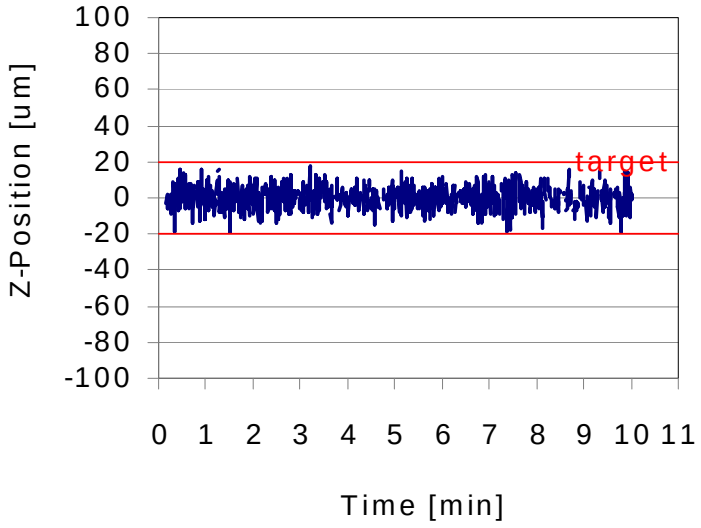
| | |
|---|---|
| Diameter: | 60um |
| Stability : | ±13um |
| Velocity: | 60msss/s |
| Frequency: | 400kHz |





**Droplet experimental chamber**

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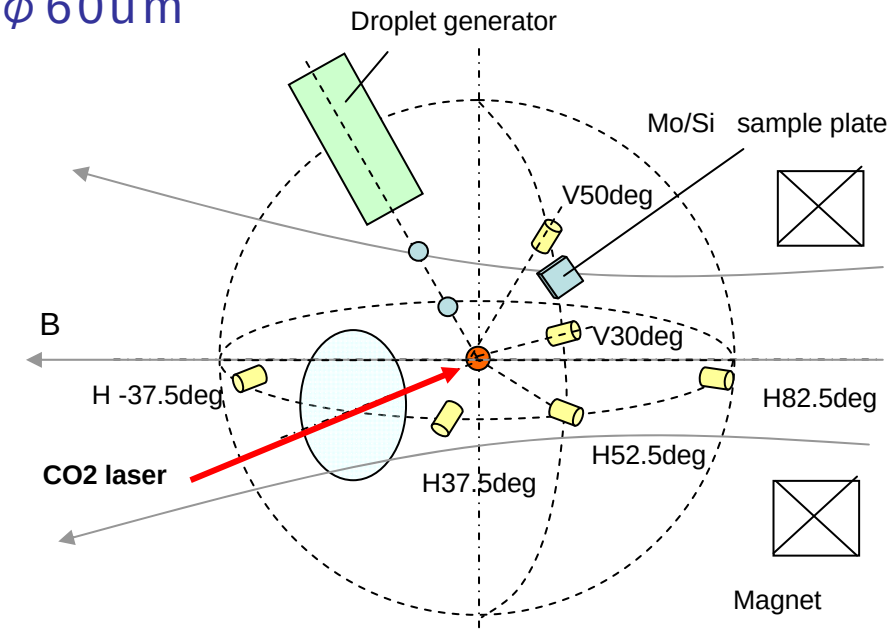
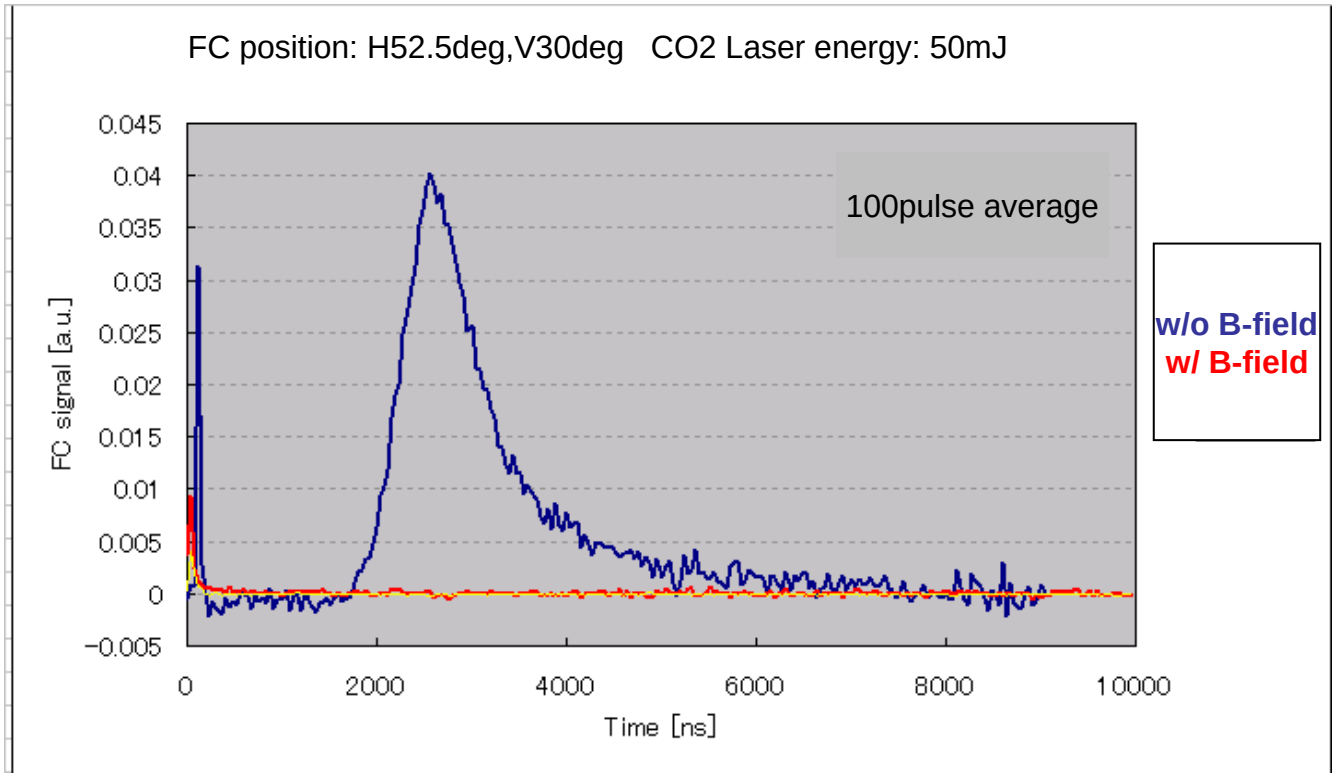
# Mitigation Experiment

- 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; $\phi$60um



# 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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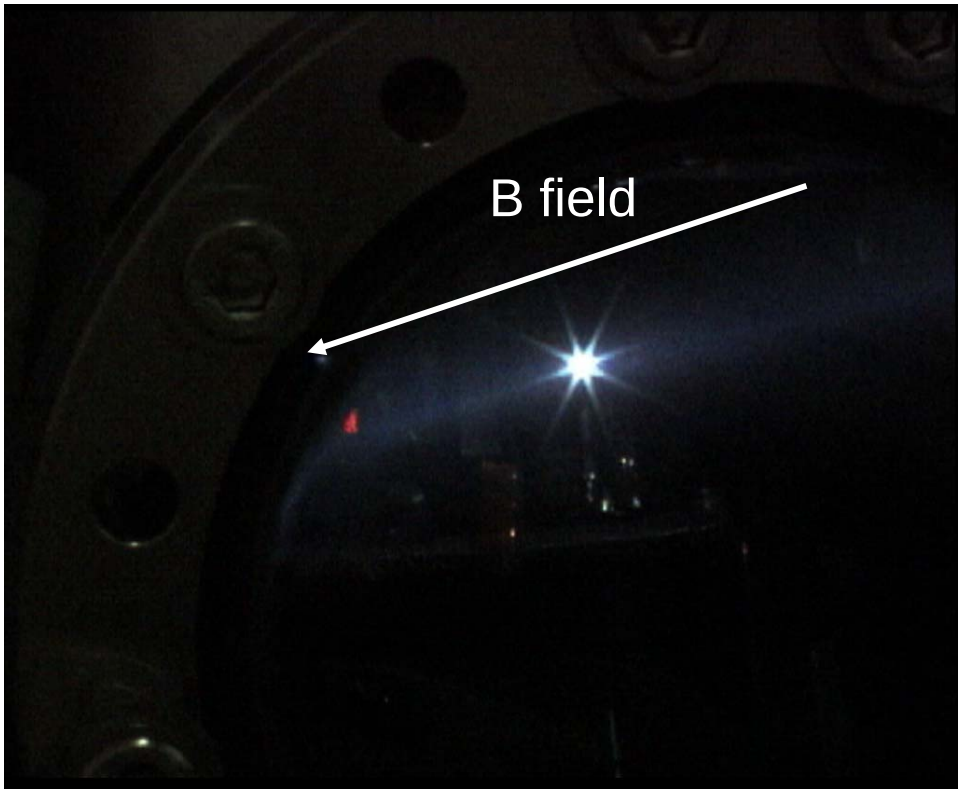
# EUV Plasma Light




- ✓$CO_2$ 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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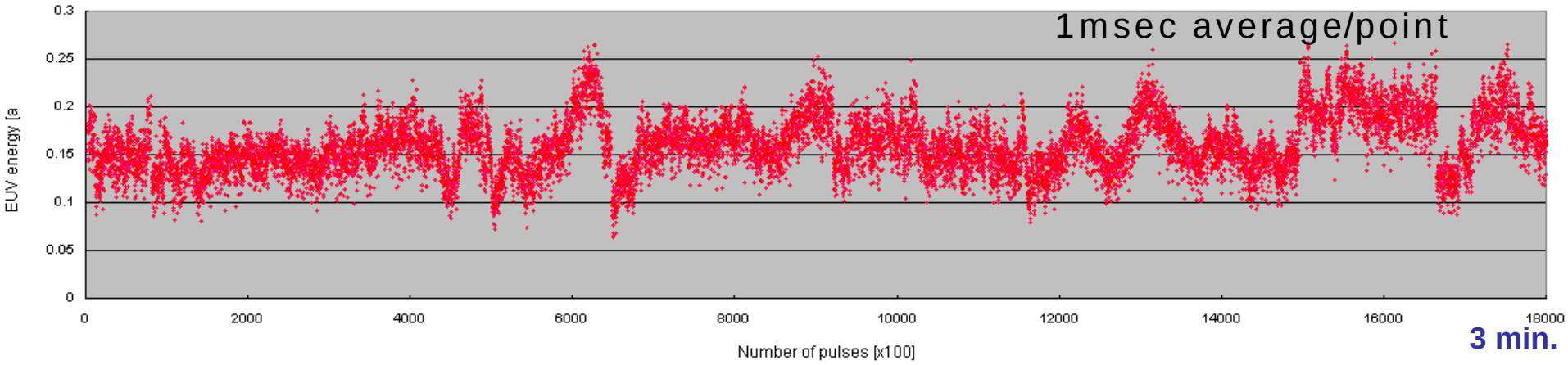


**3 min.**

- ✓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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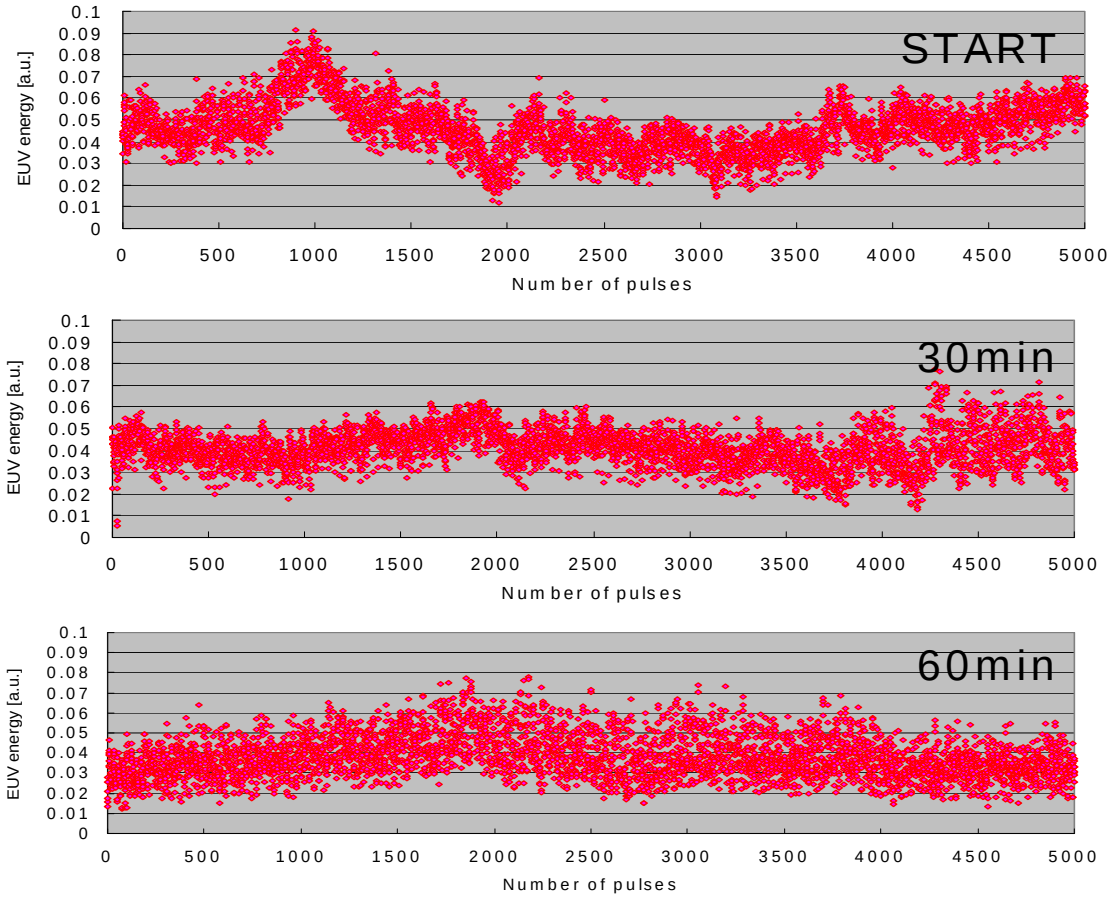
# EUV Energy w/o pre-pulse

- Long term operation

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

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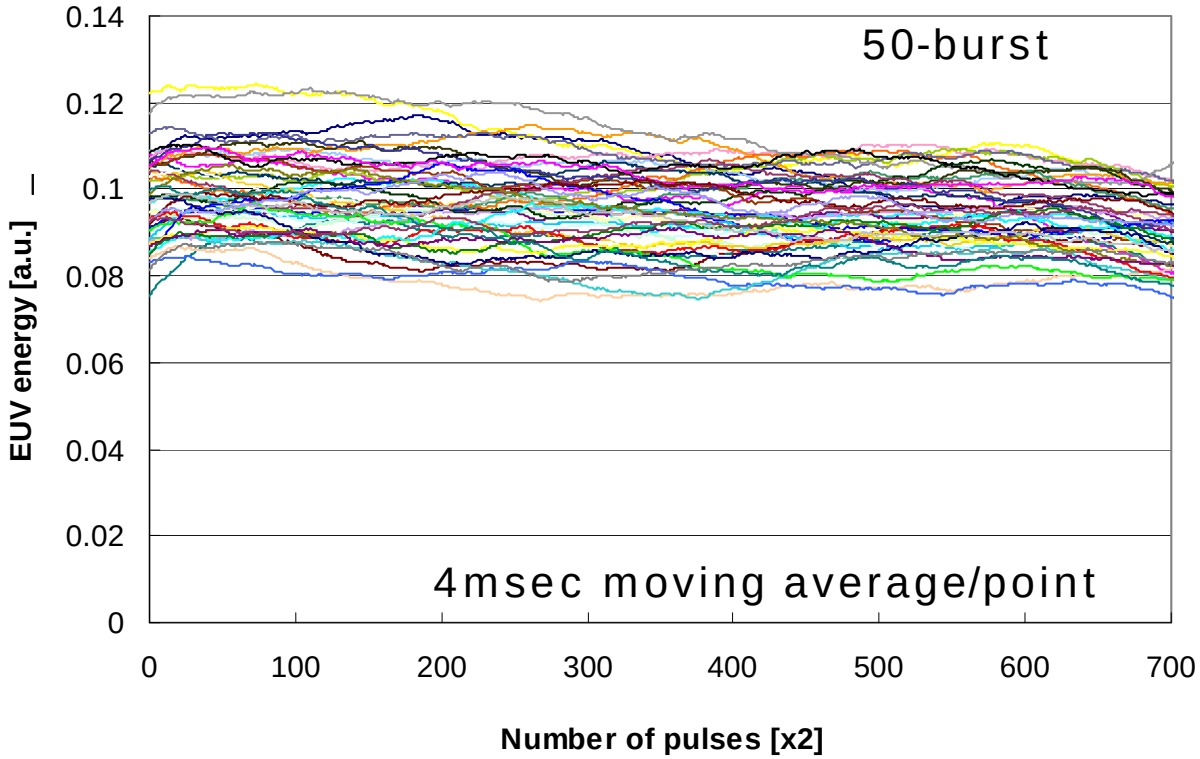
# EUV Energy w/o pre-pulse

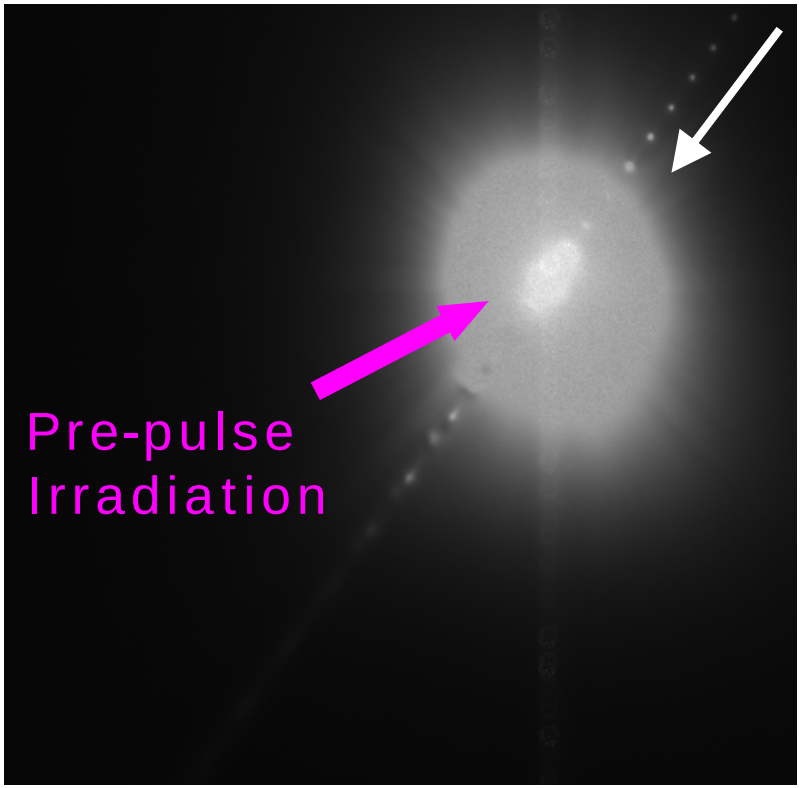
## ➢Burst mode stability




✓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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