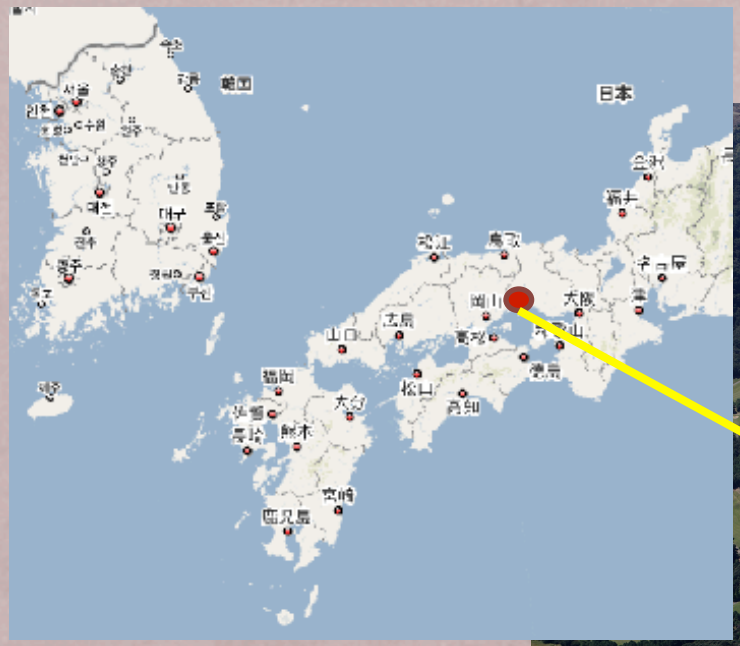
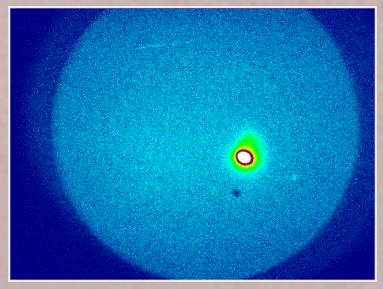
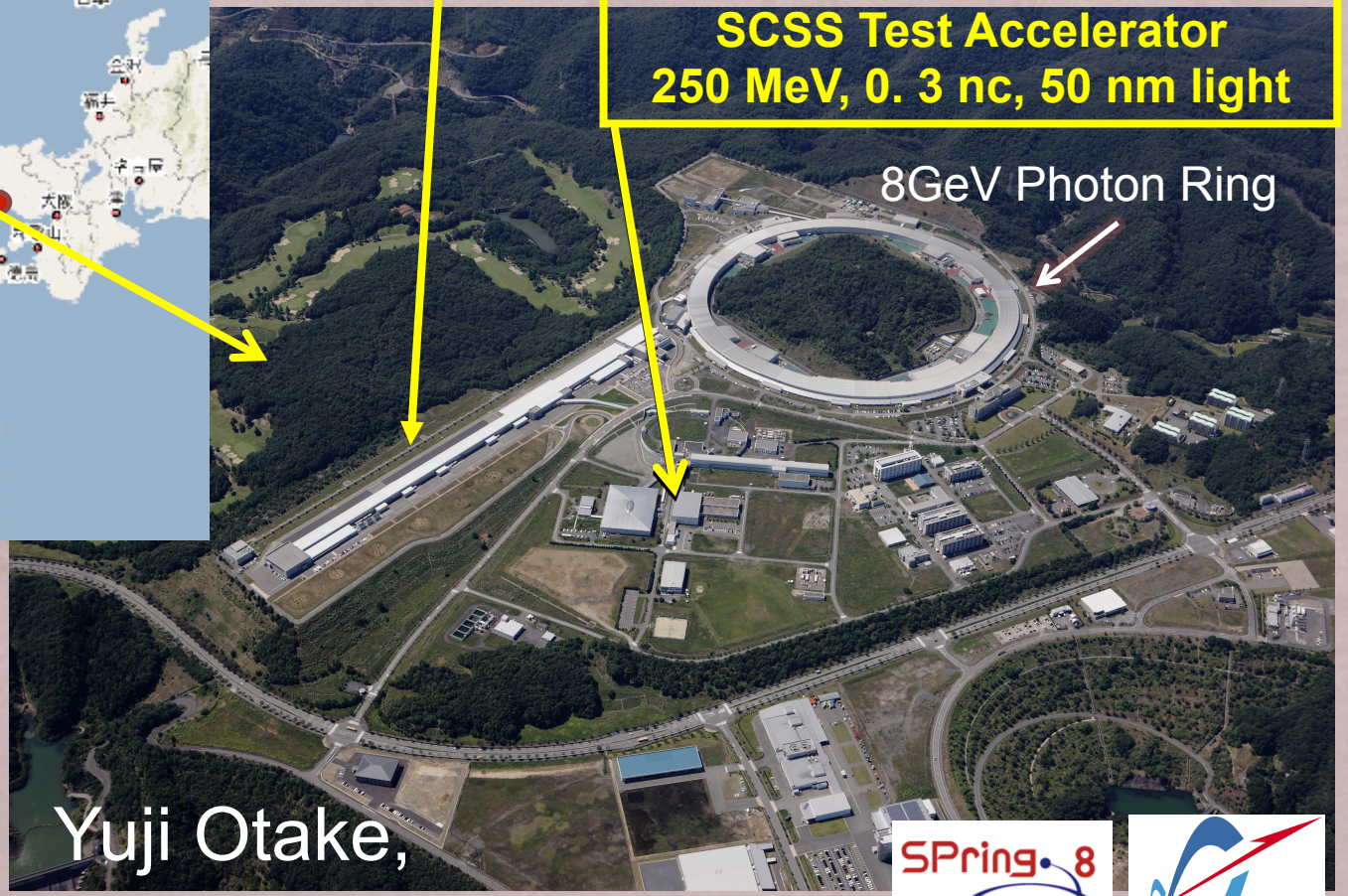
Overview of SACLA Present Status





XFEL 8Gev, 0.3 nc, 0.06 nm light

SCSS Test Accelerator
250 MeV, 0. 3 nc, 50 nm light



Yuji Otake,

on behalf of all the staffs of SACLA

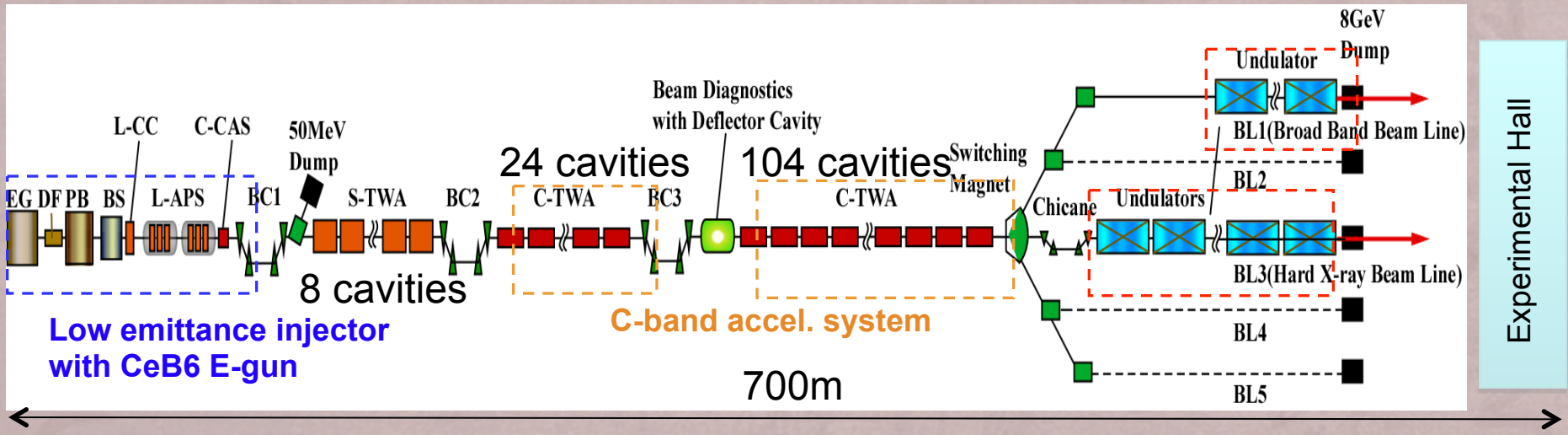
XFEL Research & Development Division,
RIKEN SPring-8 Center, RIKEN Harima Institute

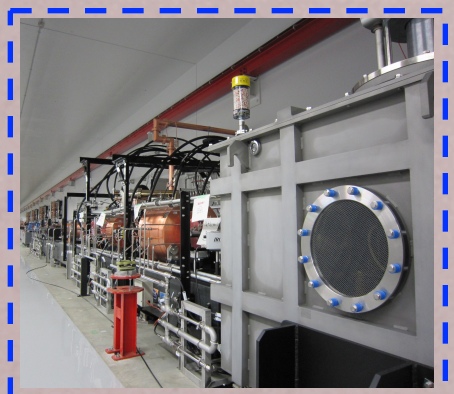
Machine Configuration

Compact XFEL based on 1. Low-emittance thermionic electron gun, 2. C-band high-gradient acceleration and 3. in-vacuum UNDs designed to realize;

(a) small scale
(b) laser stability
(c) operation reliability

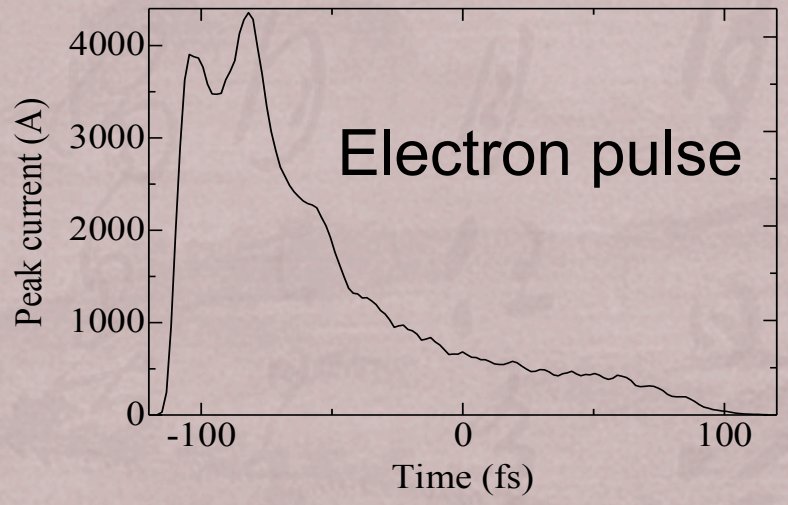
Short-period In-vacuum undulators

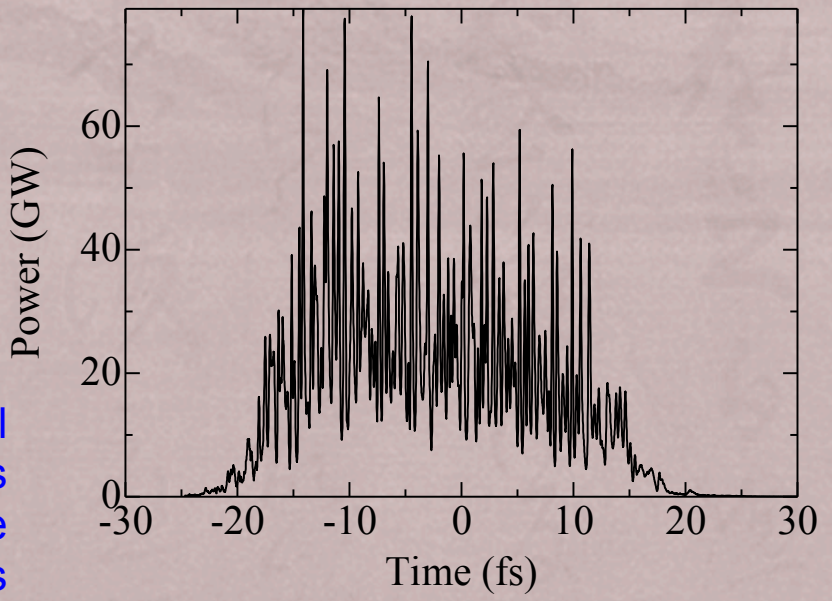




TARGET PERFORMANCE OF "SACLA"

Wavelength	< 0.1 nm
Peak Power	~ 20 GW
X-ray Pulse Length	200 fs ~ 20 fs
X-ray Pulse Energy	Max 0.4 mJ
Photon Flux	2 x 10^{11} p/pulse
Peak Brightness	1 x 10^{33} p/mm^2/ mrad^2/0.1% BW
Repetition	~ 60 pps
e Beam	8 GeV x 0.3 nC 0.8 πmm.mrad, 3 kA

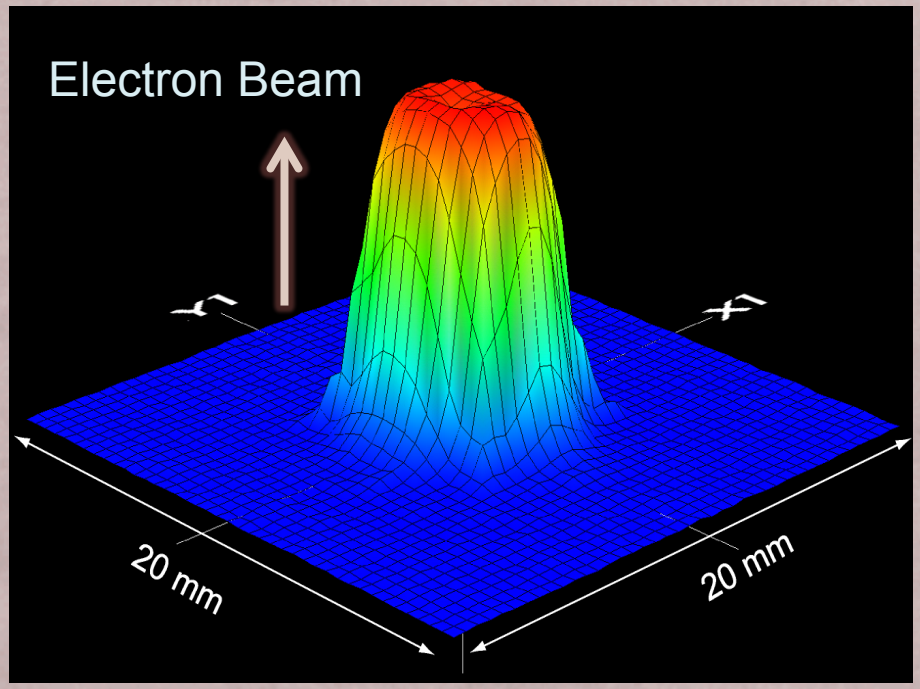




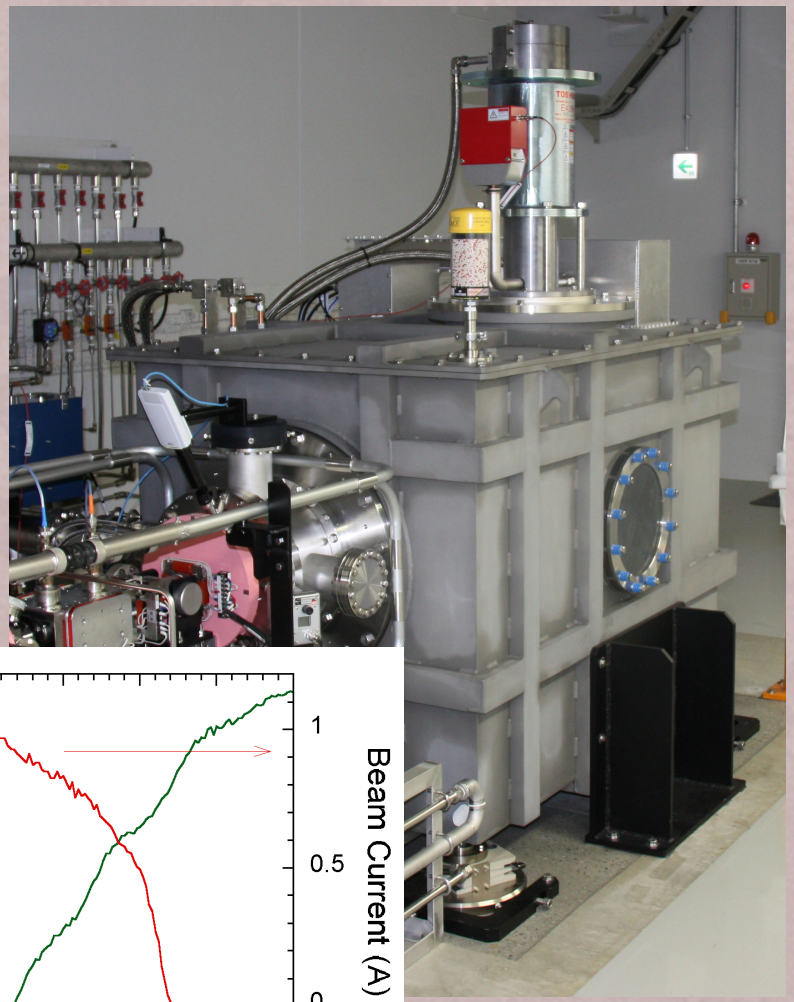
Target X-ray pulse of 0.1 nm (SIMPLEX simulation)

To realize this X-ray laser performance, the temporal electron beam stability must be less than 100 fs during the bunching process. Therefore, the demanded rf phase & amplitude stabilities are less than 100 fs & 10^{-4} in the bunching process confirmed by simulation.

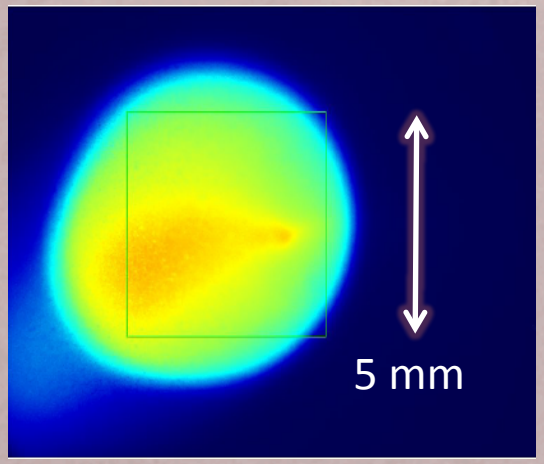
Low-emittance Electron Gun

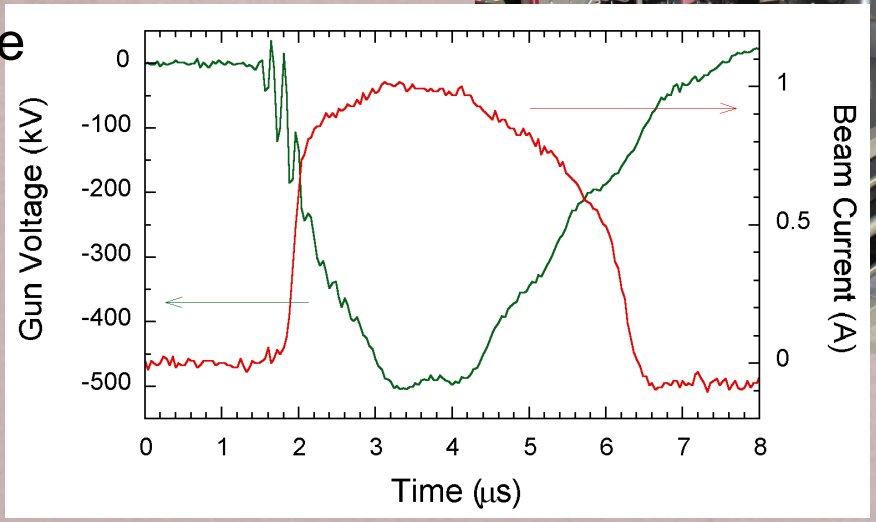


CeB6 500 kV pulse electron gun



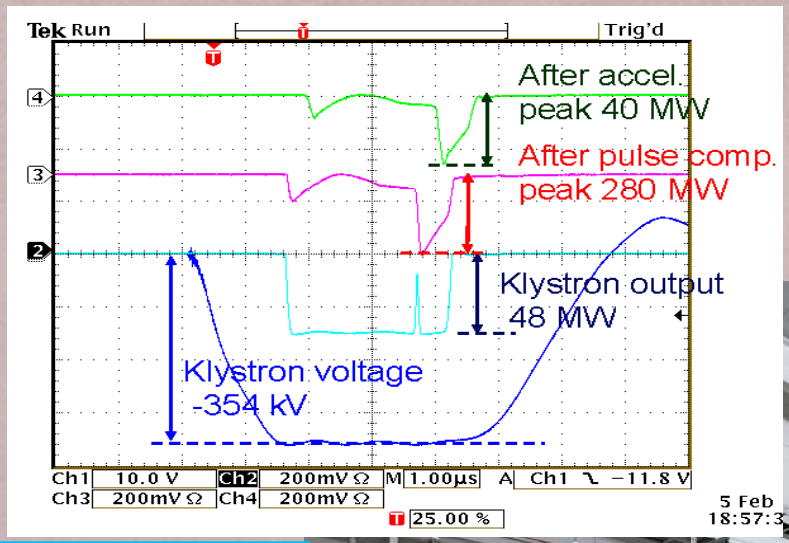
Transverse Beam Profile

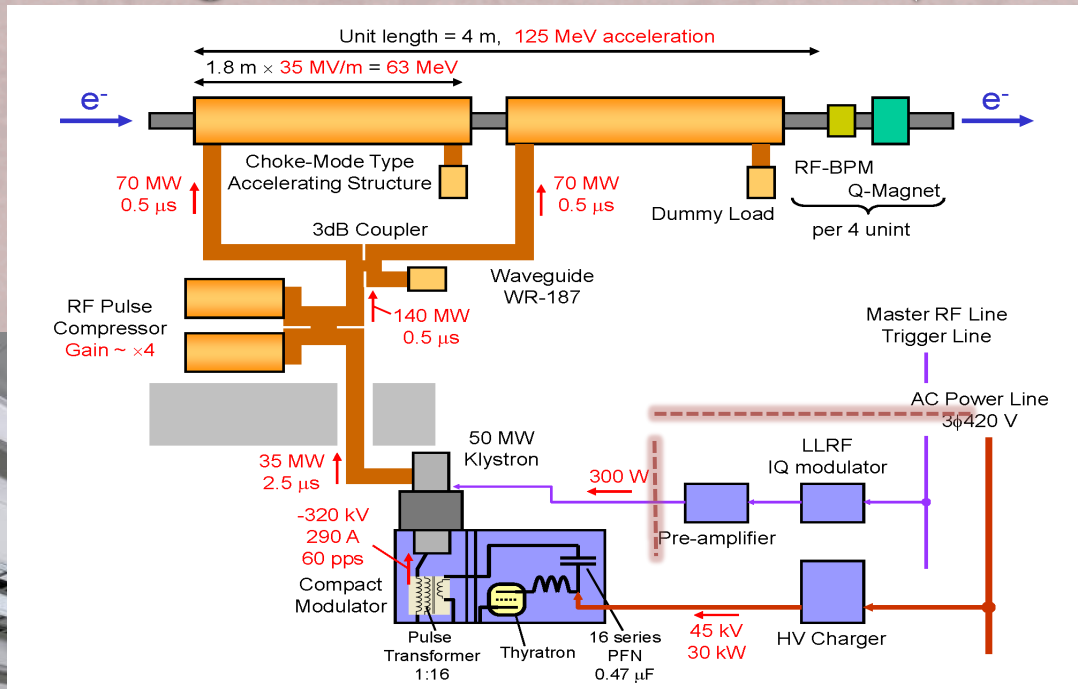




500 kV, 3 μs(FWHM) pulse and 1A electron beam

C-band Acceleration Unit to generate over 37 MV/m

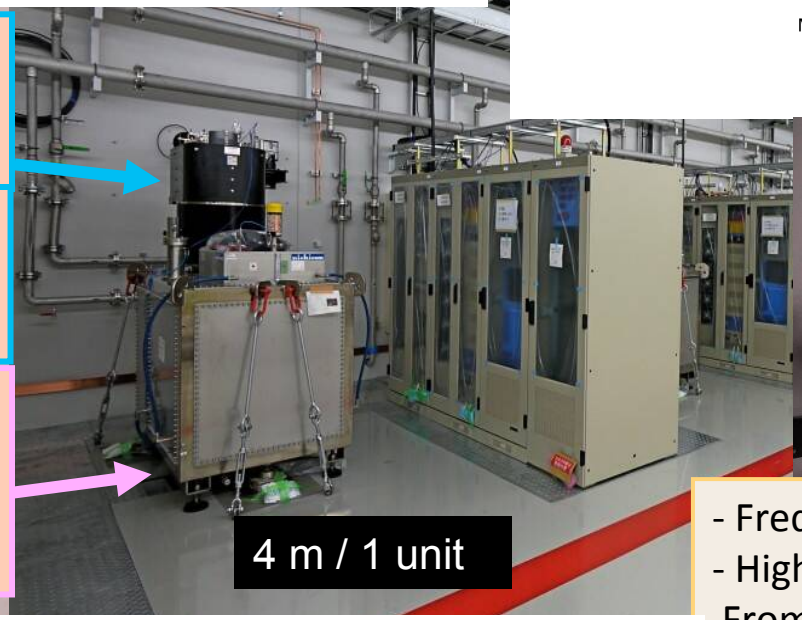


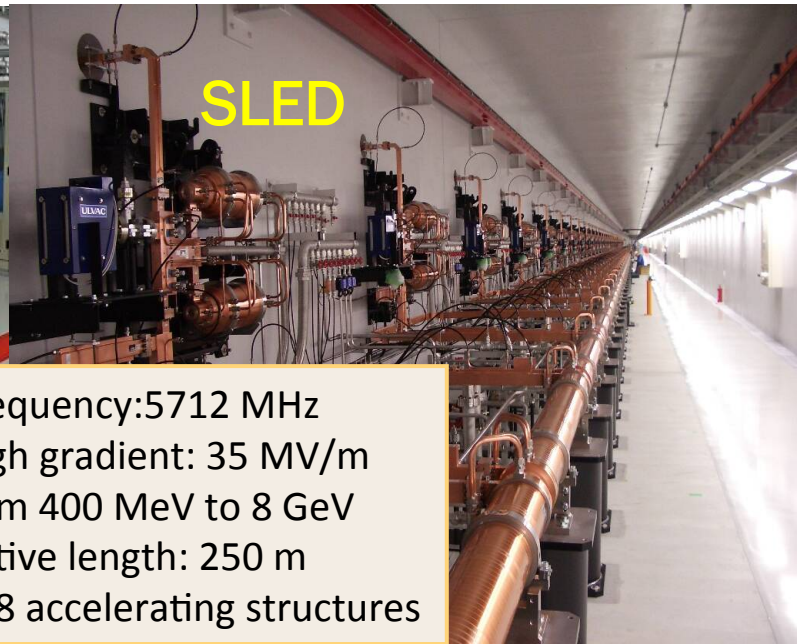


65 C-band Klystrons
50MW

4 S-band 50MW
& 1 L-band
Klystrons 20MW

70 Compact Modulators
−350 kV
110 MW



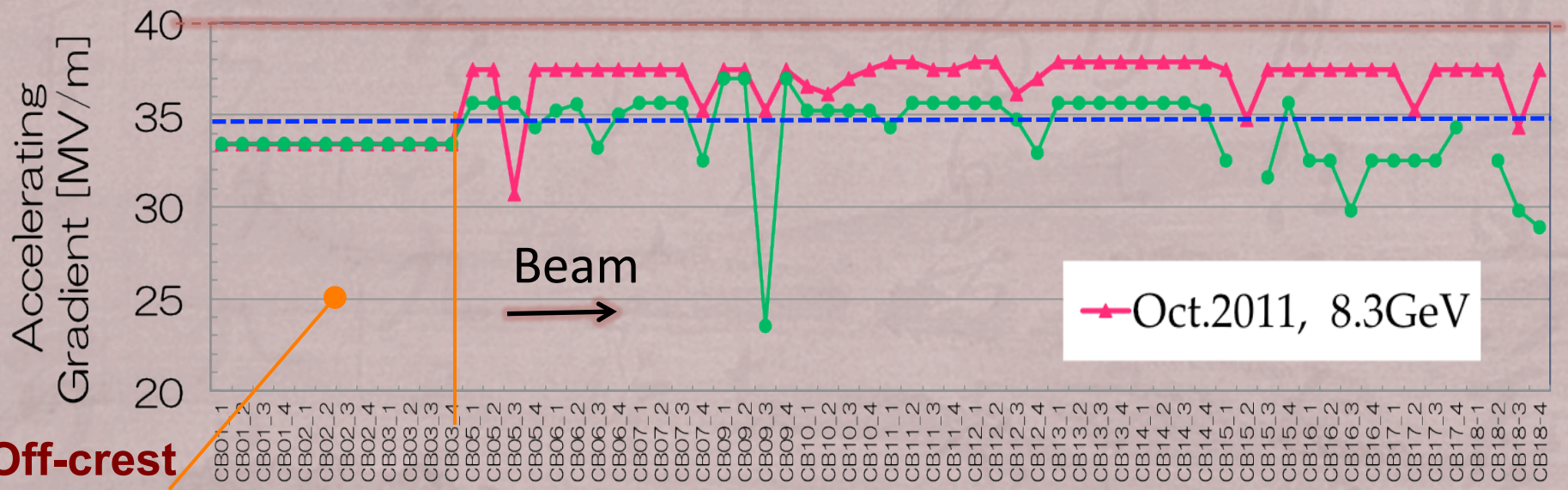


High voltage stability, 6.7 ppm (std)

- Frequency:5712 MHz
- High gradient: 35 MV/m
  From 400 MeV to 8 GeV
- Active length: 250 m
- 128 accelerating structures

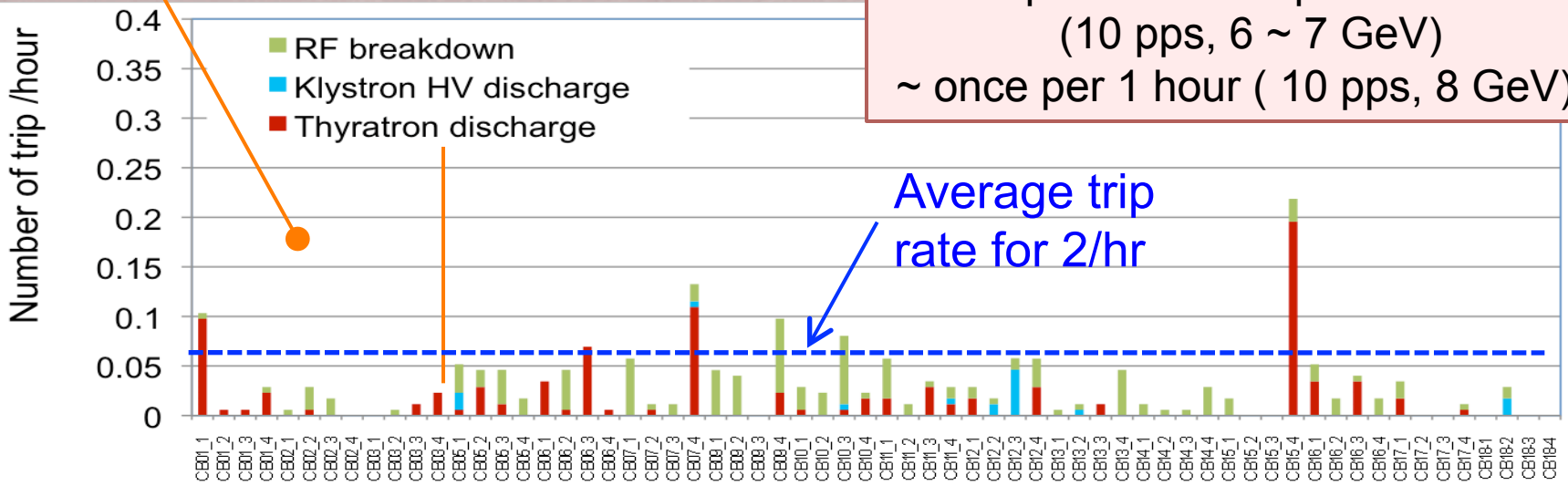
Acceleration Gradient & RF Trip Rate

RF System Satisfying a Target Gradient of 35 MV/m



Off-crest accel.

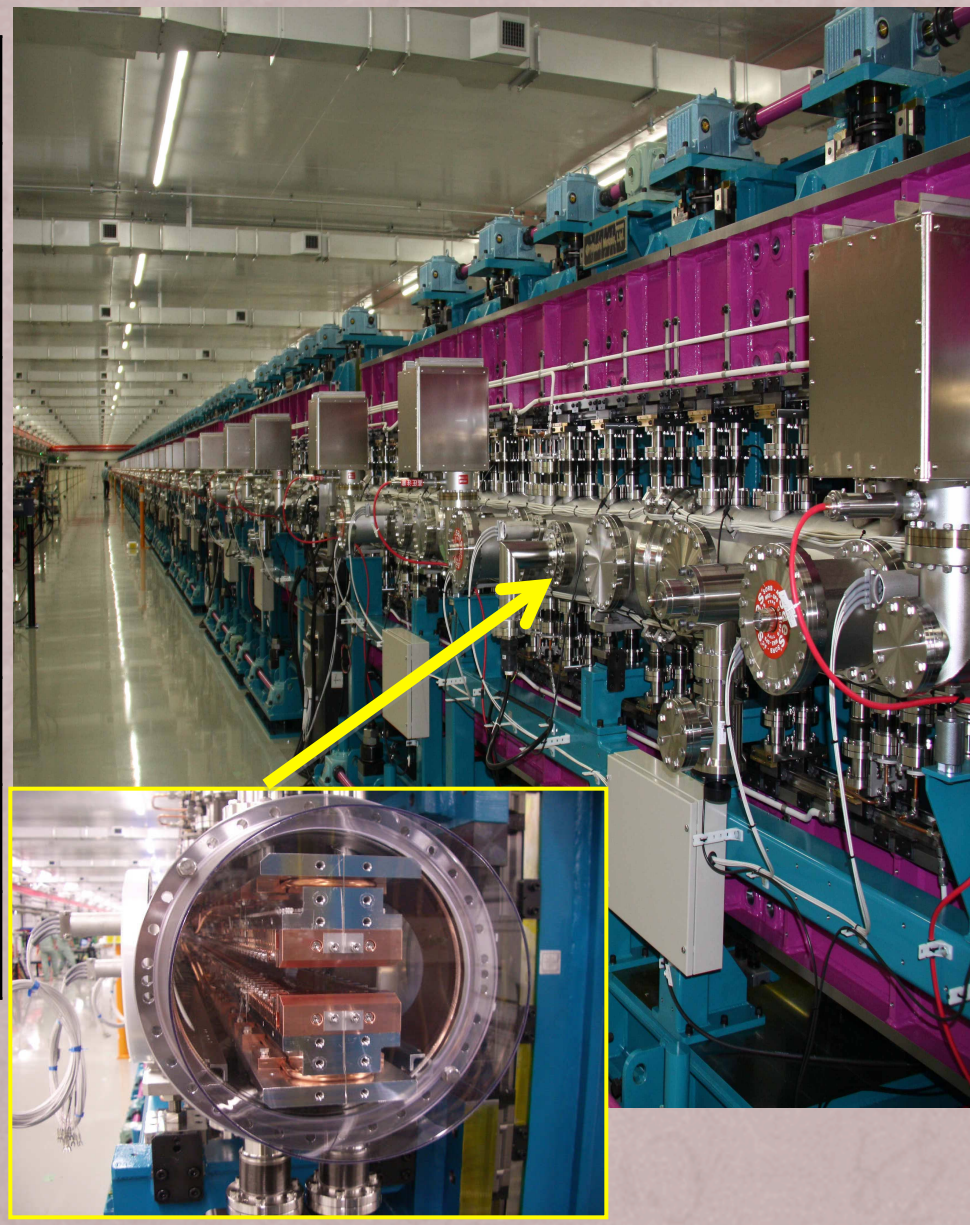
Total trip rate ~ once per 3 hours
(10 pps, 6 ~ 7 GeV)
~ once per 1 hour (10 pps, 8 GeV)



Undulator Specifications

XFEL Undulator Main Parameters

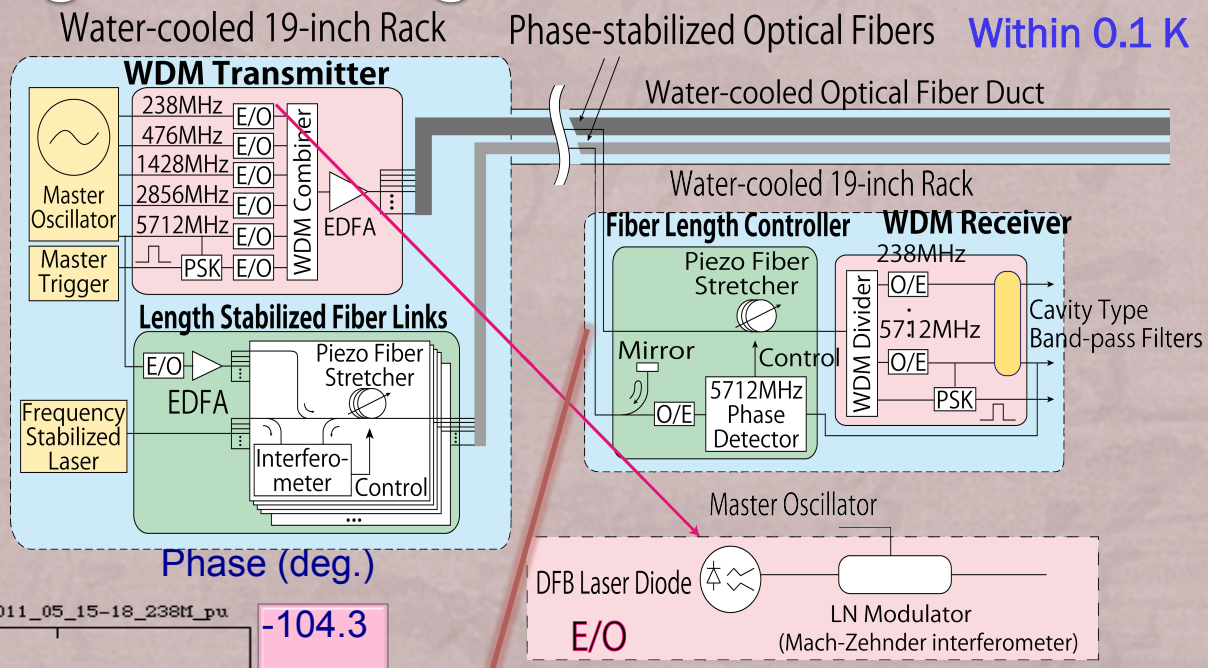
Magnet Structure	Hybrid Type
Material	NdFeB
Length (m)	5
Period Length (mm)	18
Number of Periods	277
Number of Undulators	18
Minimum Gap (mm)	3.5
Maximum K	2.2
K@λ=0.12 nm, E=7 GeV	~1.8

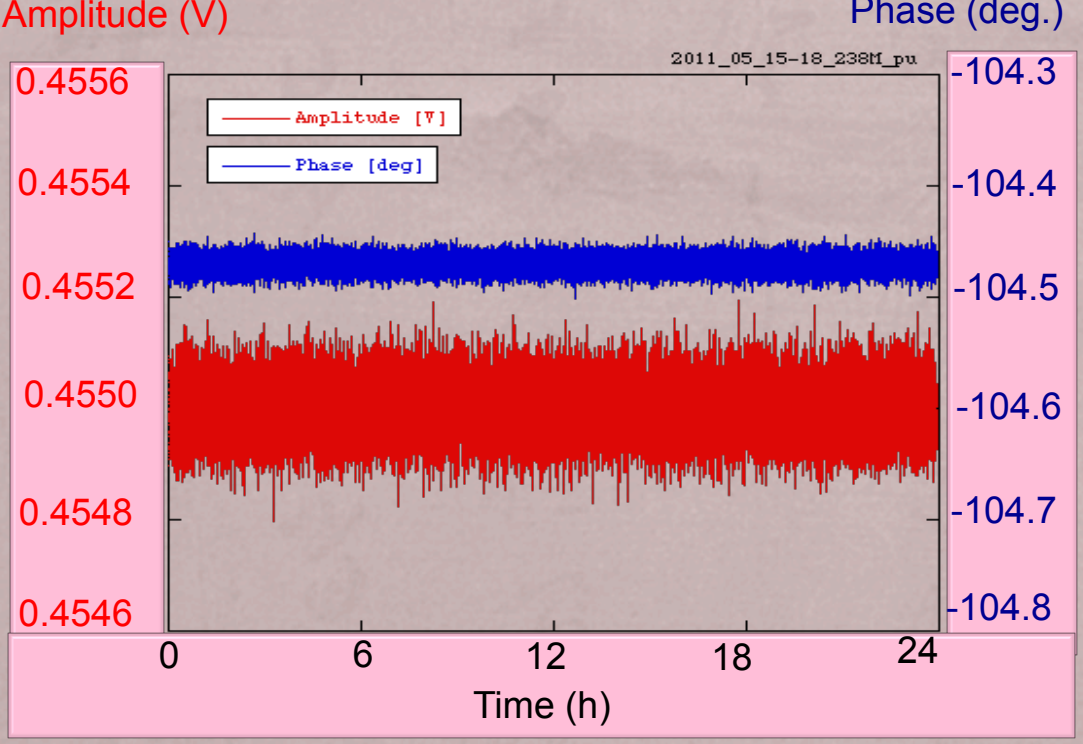


Magnetic Phase Error, 3.3 deg.

Optical rf & timing WDM Signal Transmission

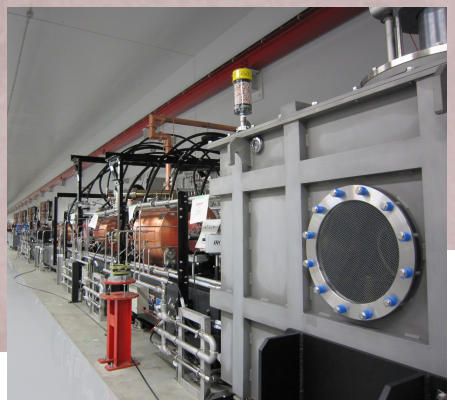
Phase and amplitude stabilities of the 238 MHz SHB. The phase stability is 0.0067 deg. in rms and the amplitude stability is 1×10^{-4} in rms for 24 hours.



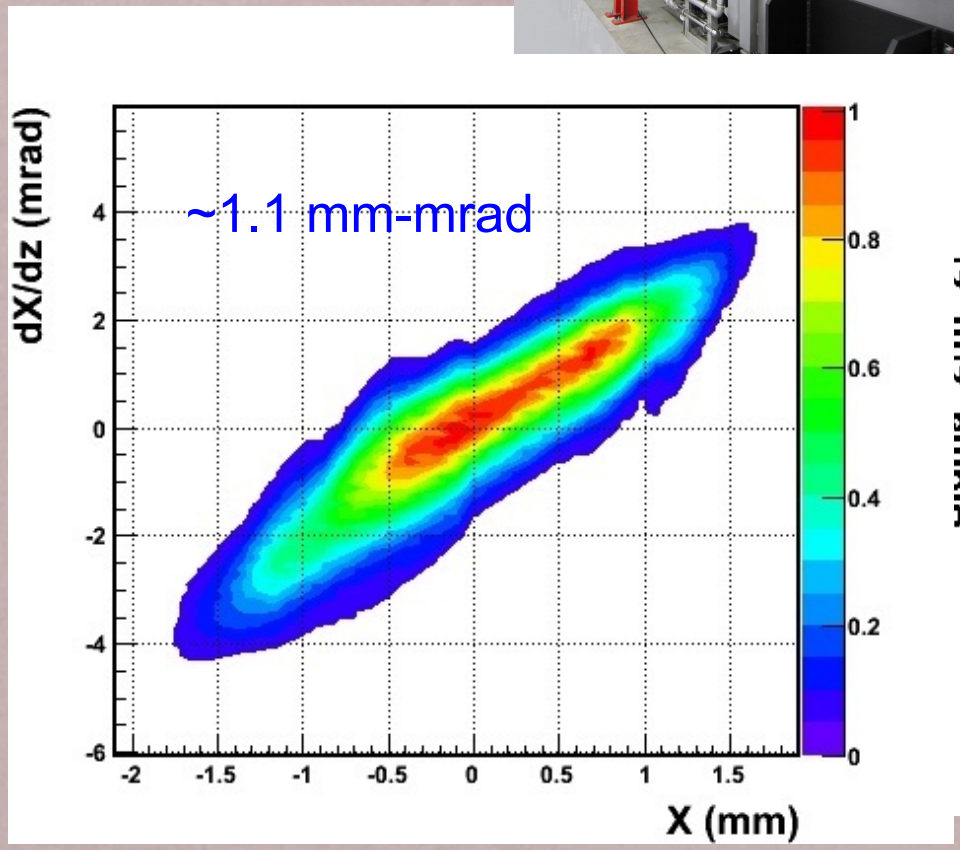


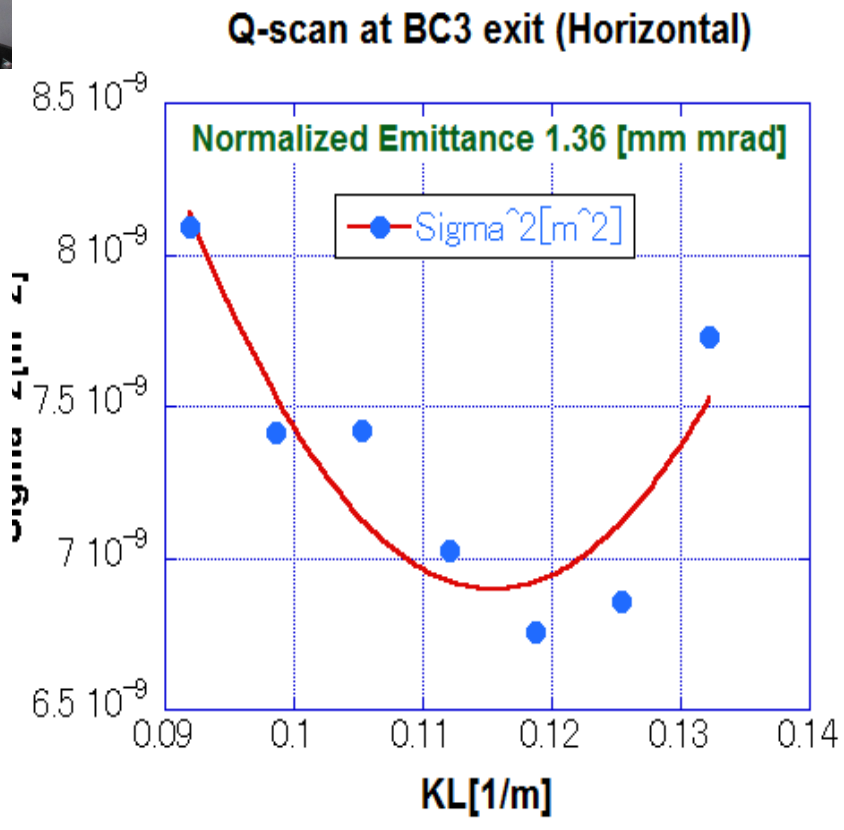
Electron Beam Normalized Emittances

Extracted e-beam
from e-gun
Energy = 500 keV
Measured by slit-scan

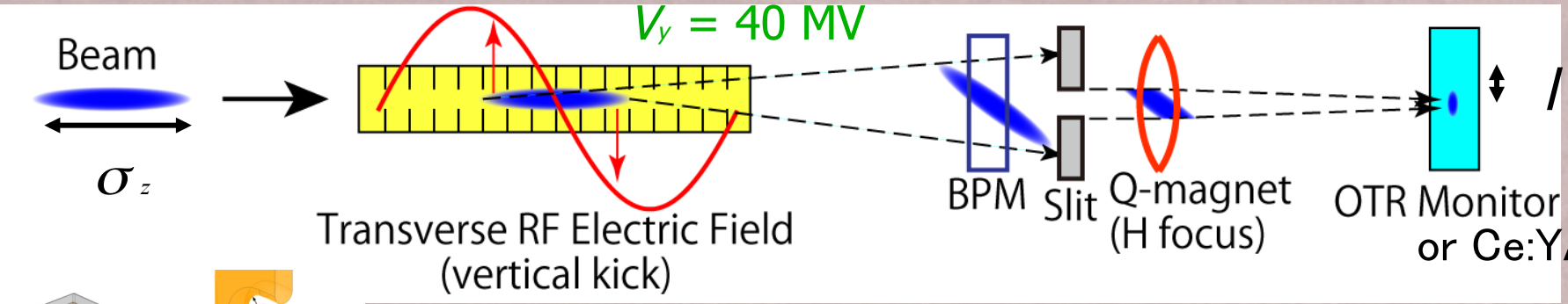


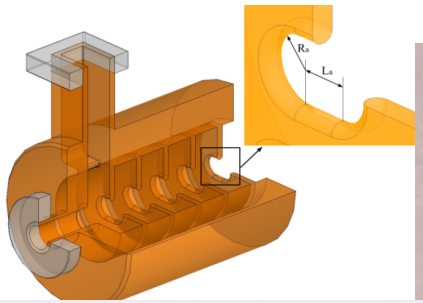
1.36 mm-mrad in horizontal
1.68 mm-mrad in vertical





Temporal Beam Image measured by RF Deflector

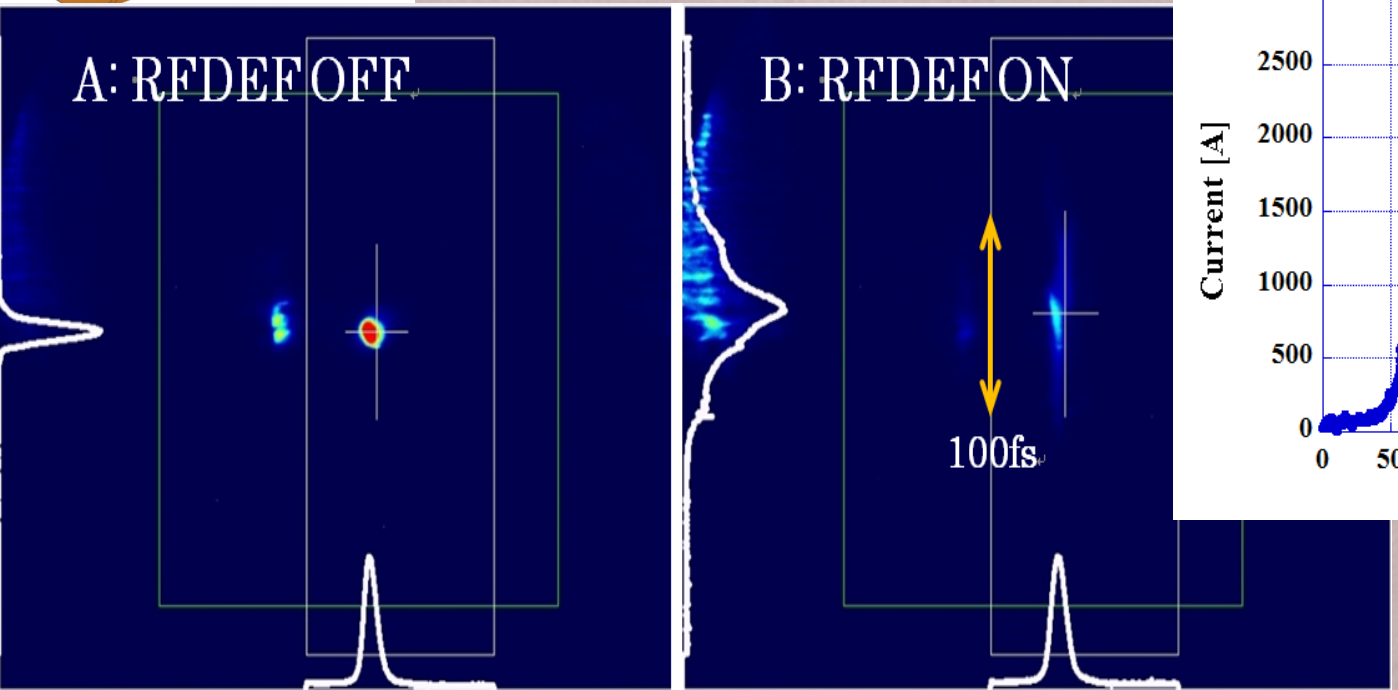


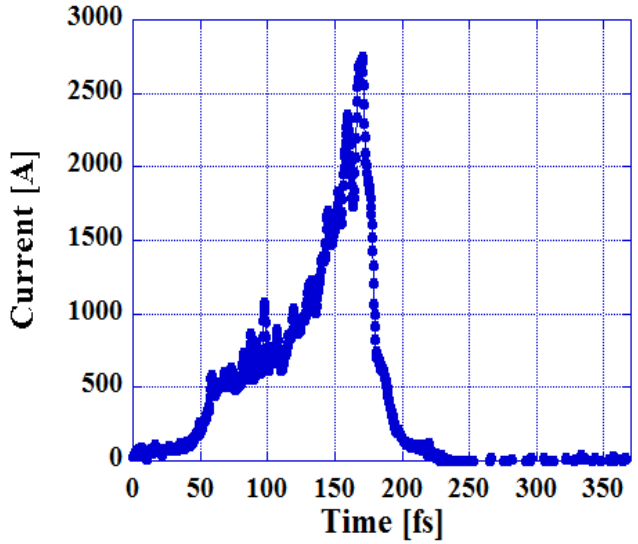


C-band HM11-mode Cavity

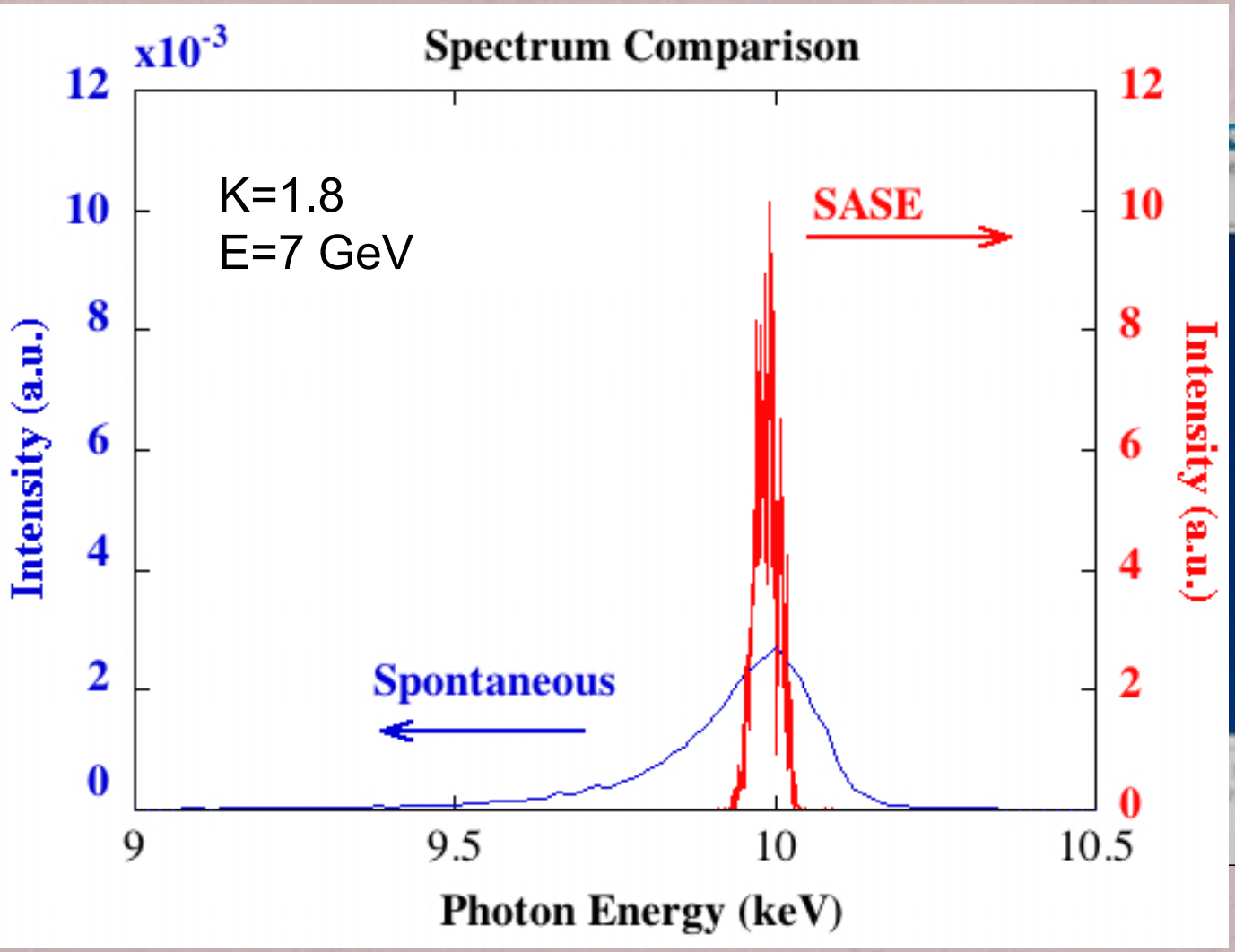
Back-ward traveling wave

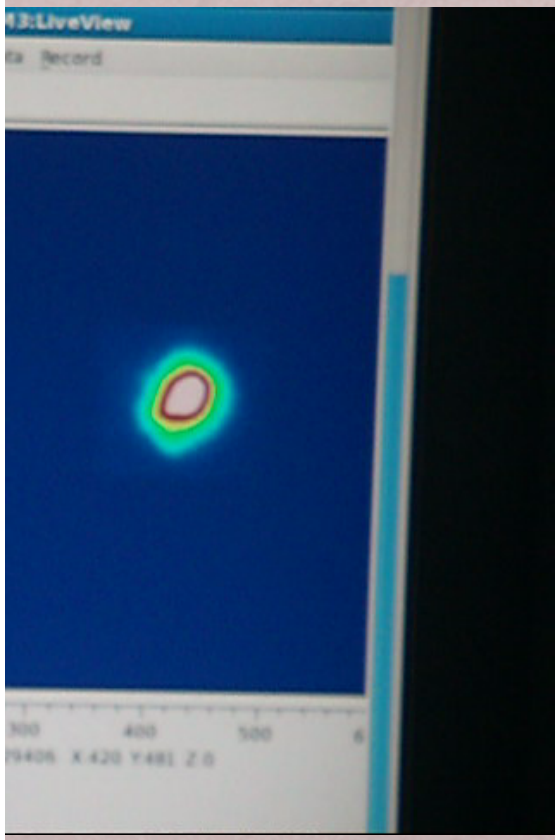
L_d = 12.5 m Drift Space





SASE & Spontaneous Spectrum

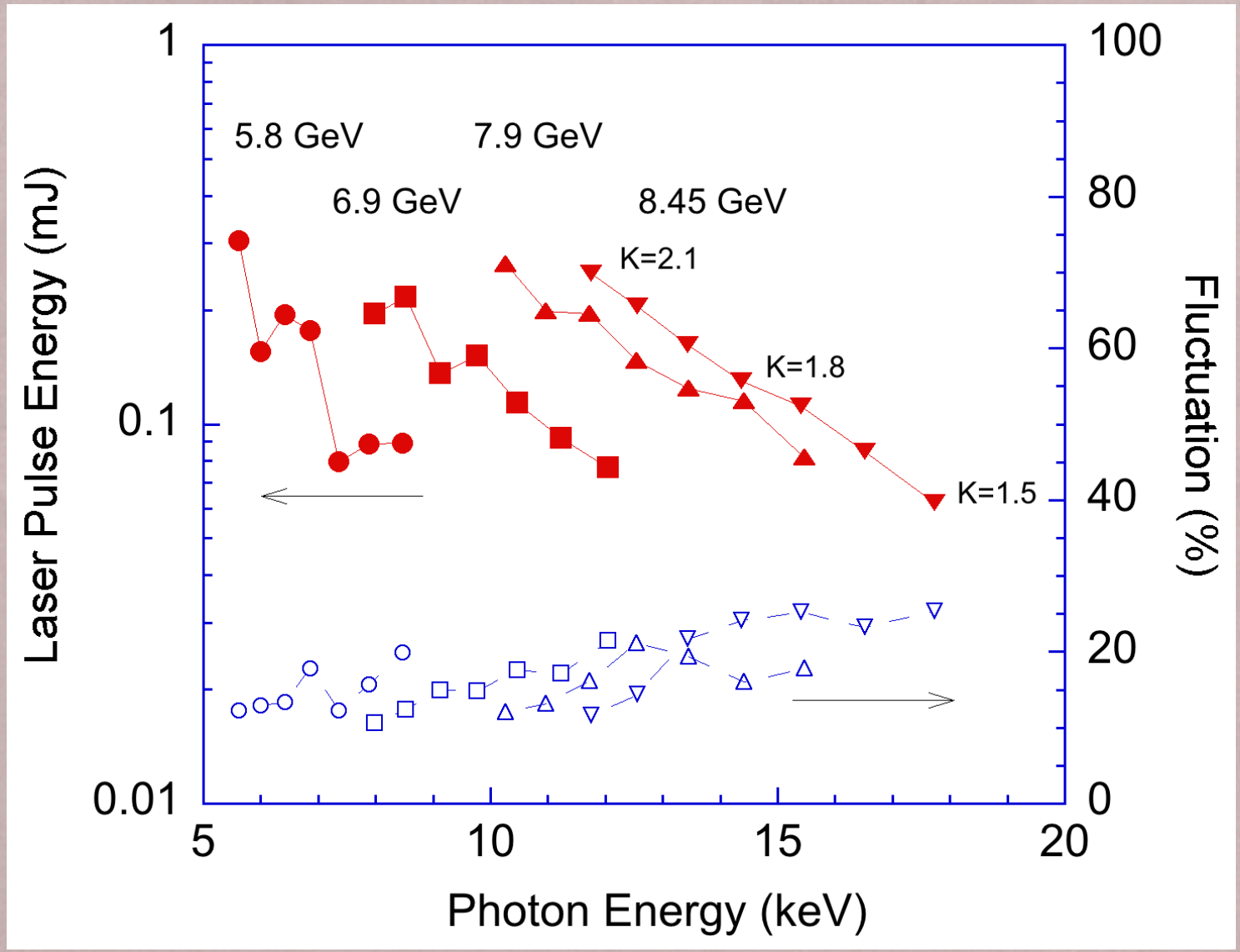




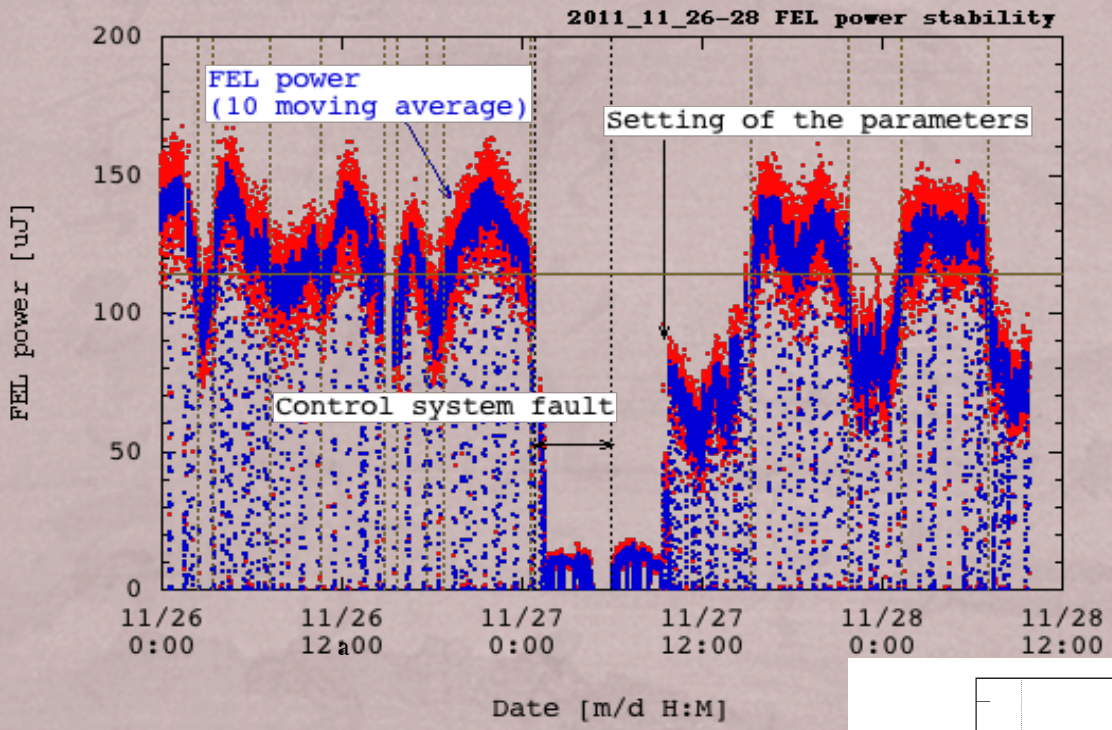
Variation of Laser Profile

λ= 0.12 nm

Wavelength Changeability of SACLA



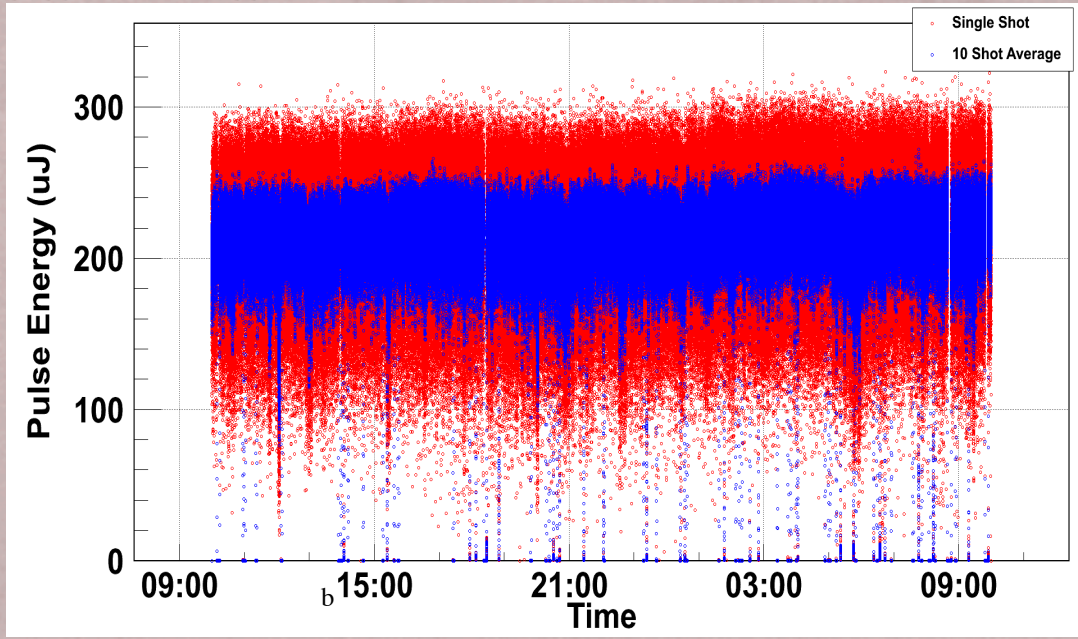
Lasing Intensity stability



a

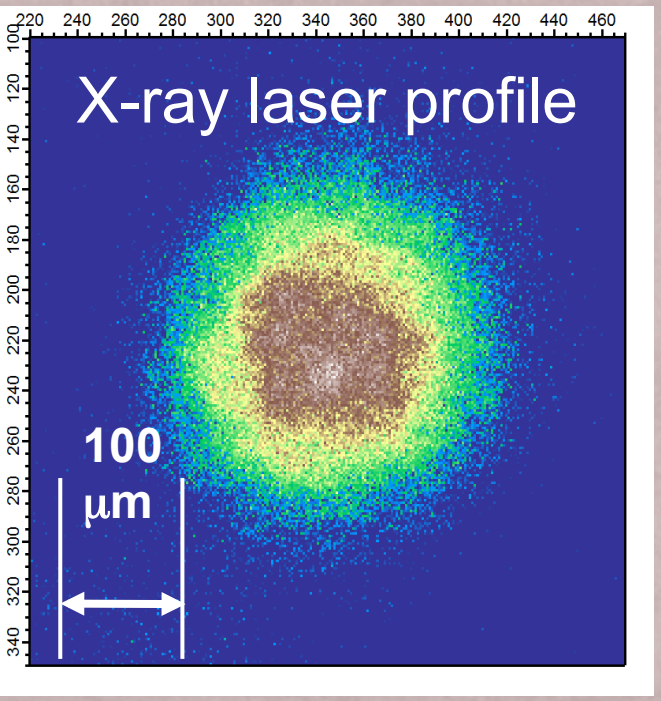
The lasing intensity stability with the operator's fine trimming for the rf phase and amplitude of the injector cavities.

The intensity variation for 3 days with the rf phase and amplitude control of all SACLA's cavities and the incident beam orbit control for BL3



b

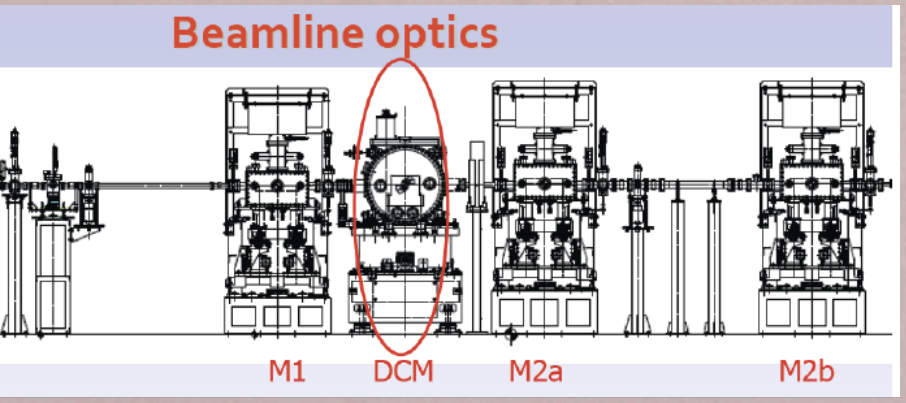
Spatial Profile of X-ray Laser



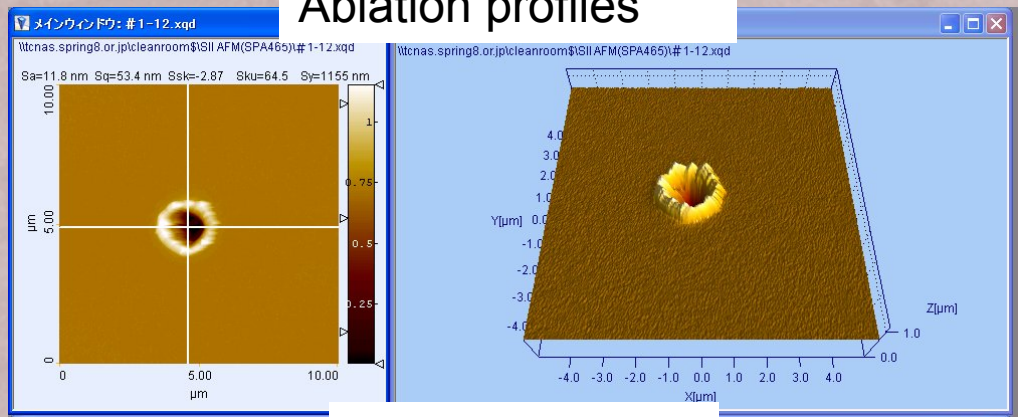
Si(111) DCM covering photon energy range from 4 to 30 keV

Focused down to 1.1 μm x 0.9 μm (FWHM)

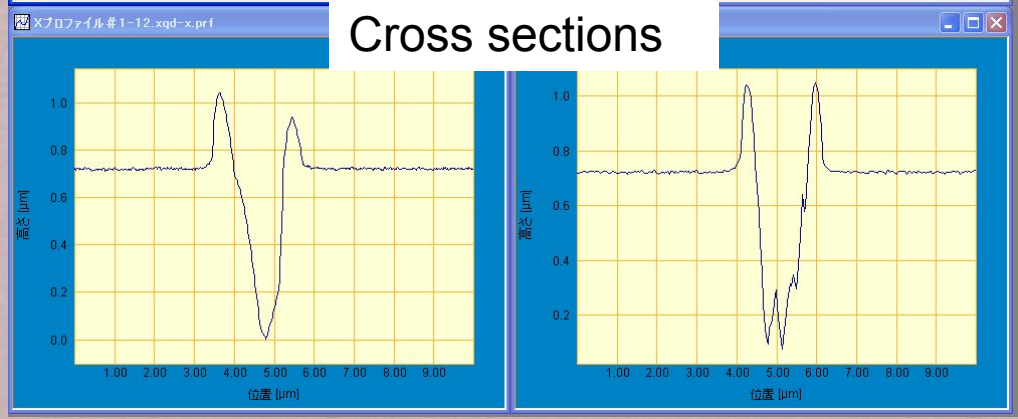
Photon energy: 10 keV
110 m from the exit of ID18



Ablation profiles



Cross sections



Ablation pattern by focused XFEL on gold-deposited film

Summary

SACLA with 700 m long was constructed (short machine). It stably lased of up to 0.06 nm for more than several days (< 100 fs electron beam temporal stability) and is now under user operation. We have an acceptable stability level of the machine with operator's trimming of once or twice a hour to the injector cavity's phases and amplitude.

Lasing intensity drift caused by the thermal characteristic drifts of accelerator components exist, however, we now improve it to become without the trimming.

Maximum pulse energy

Typ. 120 ~ Max. 250 μJ

Wavelength range

0.063 ~ 0.16 nm

Intensity fluctuation

15 % (rms)

Reproducibility

• w/o beam FB keeping the peak current

• at 60~70% of peak intensity

Related Presentations

- TUPB006, T. Asaka et al., STABILITY PERFORMANCE OF THE INJECTOR FOR SACLA/XFEL AT SPRING-8.
- MOPB005, T. Inagaki et al., HIGH GRADIENT OPERATION OF 8-GEV C-BAND ACCELERATOR IN SACLA.
- MOPB084, T. Sakurai et al., DESIGN OF A C-BAND DISK-LOAD TYPE ACCELERATING STRUCTURE FOR A HIGHER PULSE REPETITION RATE IN THE SACLA. ACCELERATOR.