Laser Pulse Stacking for X-ray Generation

Laser Wire Mini-Workshop at Oxford

Collaborators

<WASEDA University>

K. Sakaue ○, M. Washio

<High Energy Accelerator Research Organization (KEK)>

S. Araki, M. Fukuda, Y. Higashi, Y. Honda, M. Takano,

T. Taniguchi, N. Terunuma, J. Urakawa

<KYOTO University>

N. Sasao, H. Yokoyama

<TOKYO University>

H. Sakai

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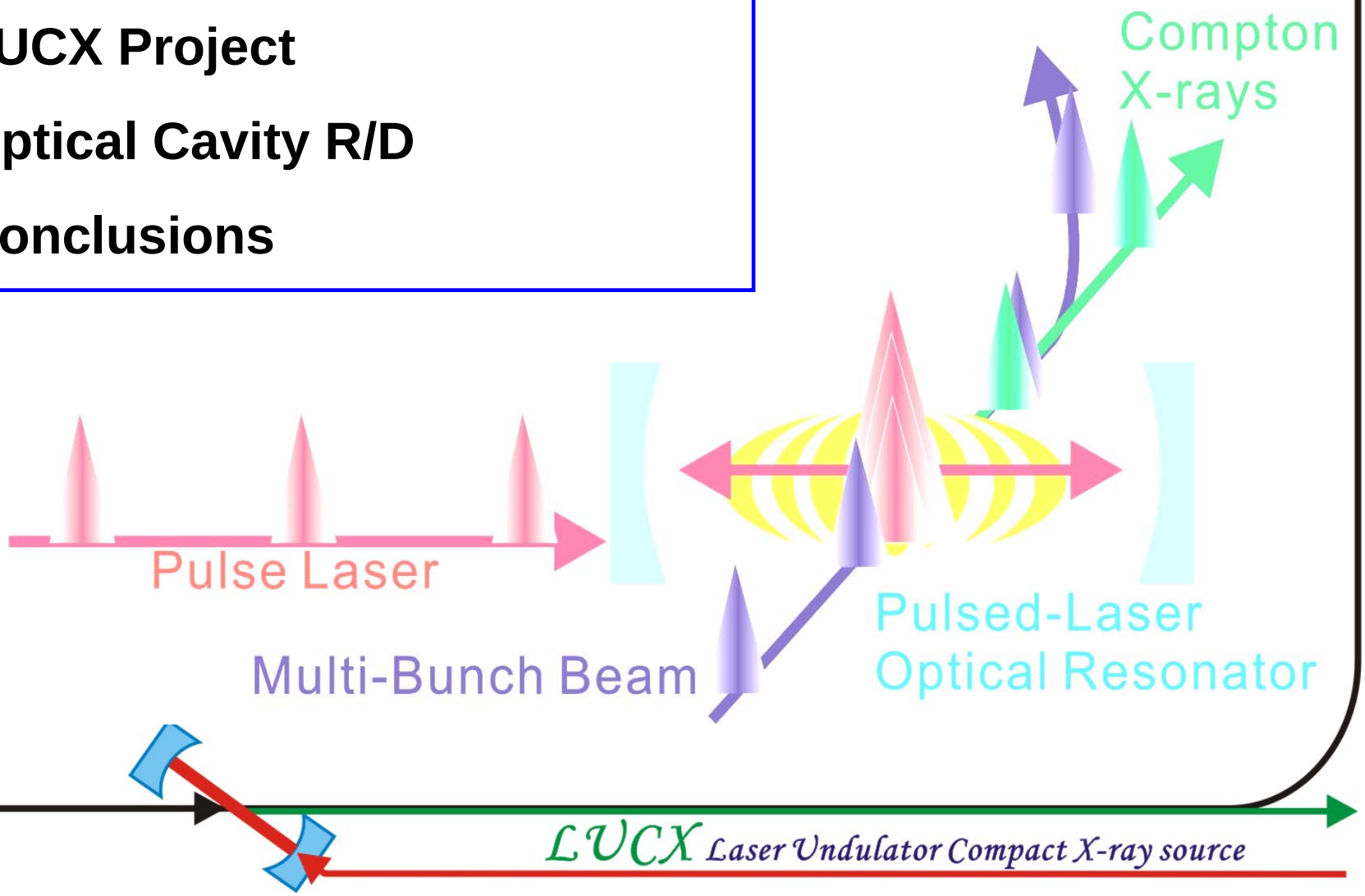


Laser Pulse Stacking ~Applications and Possibilities~

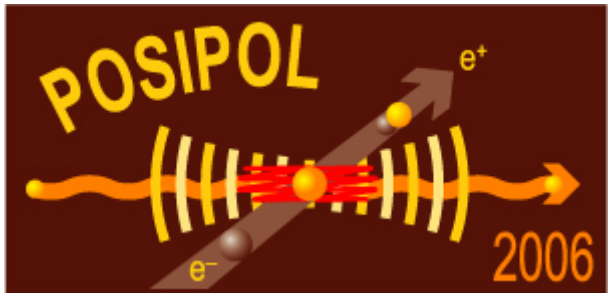
Laser Pulse Stacking
Produce a high peak power and high average power.
>Many applications and possibilities.

>Pulse Laser Wire

>X-ray Sources

LOGO
Now Preparing

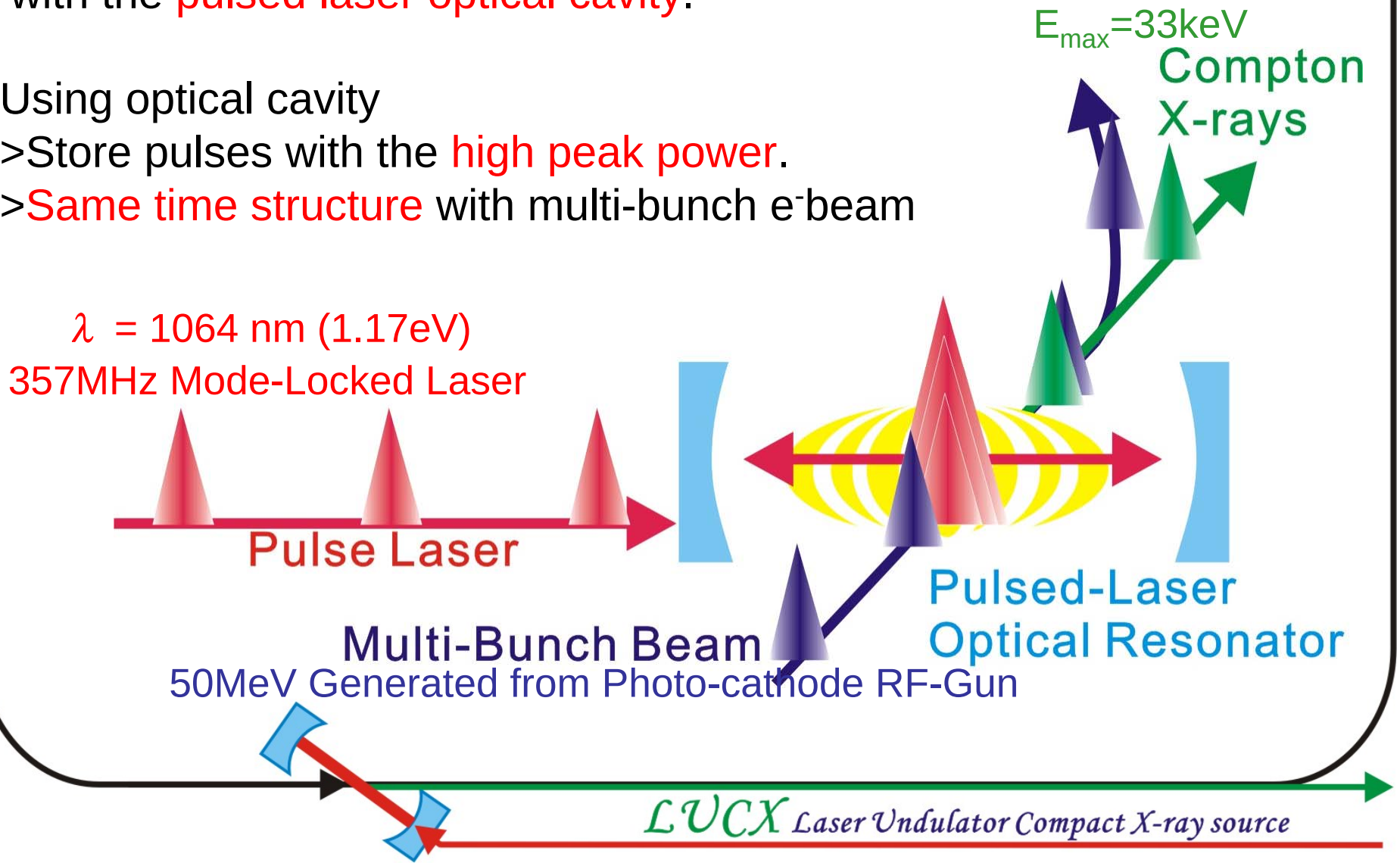
>Polarized Positron Sources for ILC



LUCX Project ~Laser Undulator Compact X-ray source~

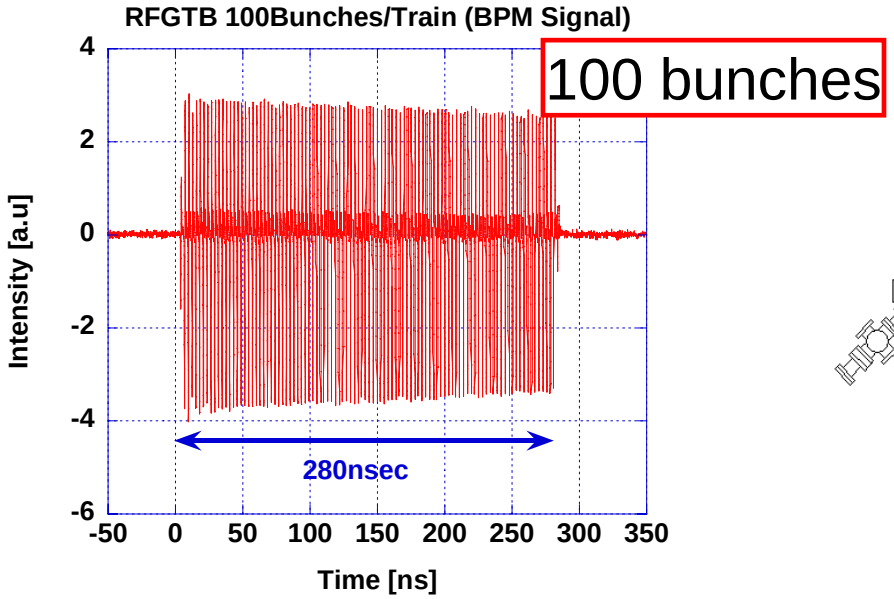
We are developing an X-ray source based on Laser Undulator with the pulsed laser optical cavity.

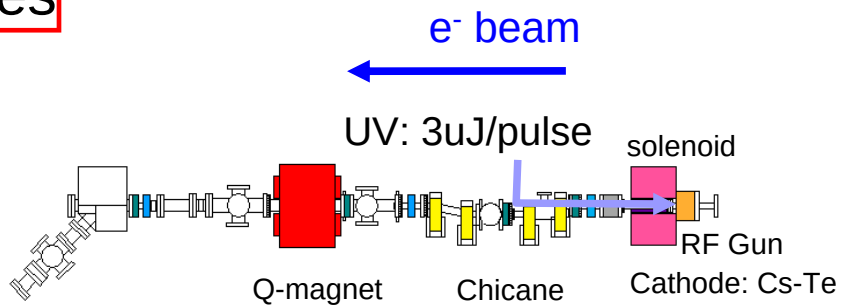
Using optical cavity
>Store pulses with the high peak power.
>Same time structure with multi-bunch e^-beam



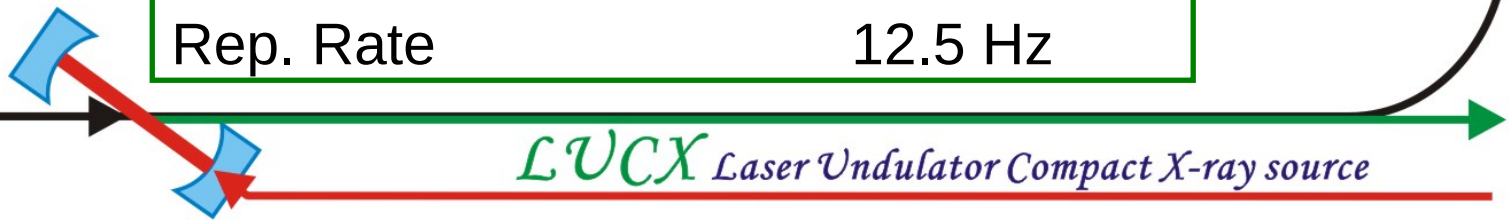
LUCX Project ~Laser Undulator Compact X-ray source~

We have demonstrated a 100bunches multi-bunch operation with Cs-Te photo-cathode RF-Gun.





Energy	5 MeV
Intensity	300nC/train
Number of Bunch	100 bunches
Rep. Rate	12.5 Hz

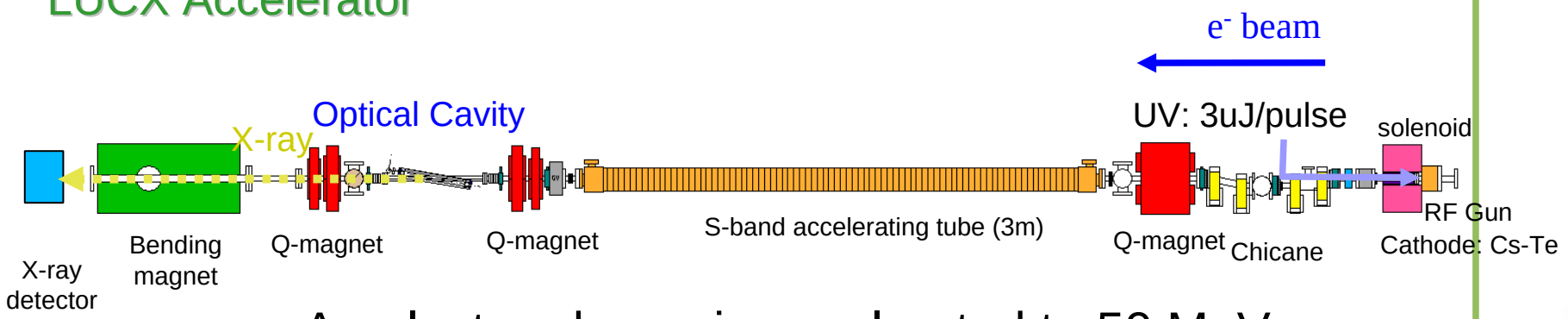


LUCX Project ~Laser Undulator Compact X-ray source~

Photocathode RF-Gun and 3m-Linac
100Bunches/Train
50MeV
Multi-bunch e^- beam

Pulsed Laser Optical Cavity
420mm (357MHz)
1064nm (Nd:VAN)

LUCX Accelerator



An electron beam is accelerated to 50 MeV.

LUCX Laser Undulator Compact X-ray source

LUCX Project ~Expected X-ray~

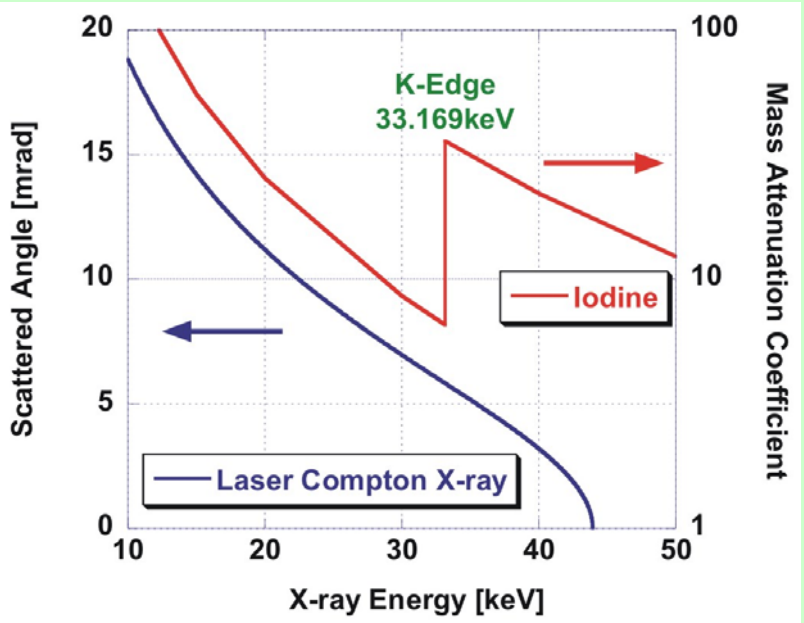
Parameter	Energy	Number	Beam Size	Repetition
Electron	50MeV	200nC /100Bunch	64um(H) 32um(V)	12.5Hz
Photon	1064nm 1.17eV	$6*10^3$Watt 17uJ/pulse	85um(H) 85um(V)	357MHz

(< 10mrad, >19 keV) corresponding to 40% of the total numb of X-ray

Take in account the acceptance (< 10mrad),

Expected number of X-rays

2.5 x 10^5 photons/sec



Optical Cavity R/D ~Pulse Laser Optical Cavity~

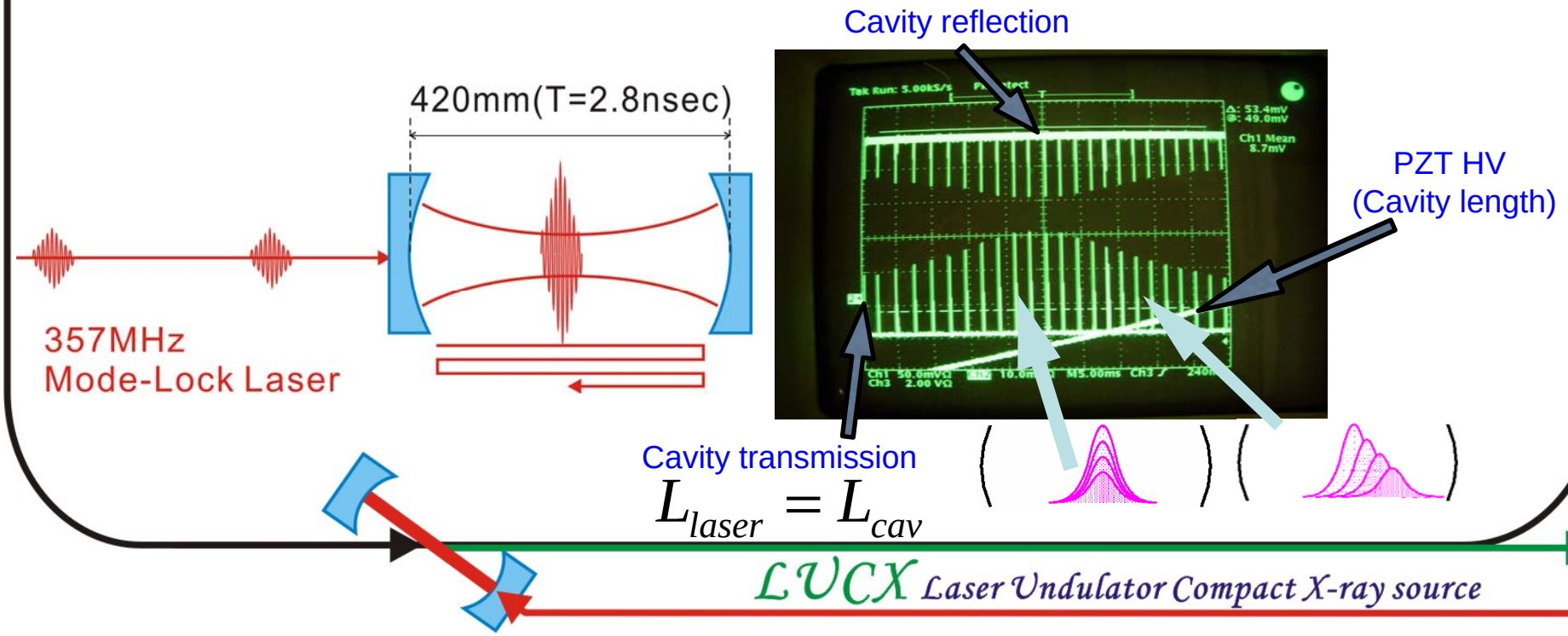
Pulse Laser Optical Cavity
Resonance condition

>**Phase relation**

Resonator length = Integer of half wavelength

>**Envelop superposition**

Laser repetition = Round trip time of the optical cavity



Optical Cavity R/D ~Pulse Laser Optical Cavity~

We will install an optical cavity next summer.

Injection Laser : >6W@357MHz

⇨ Cavity Length : 420mm

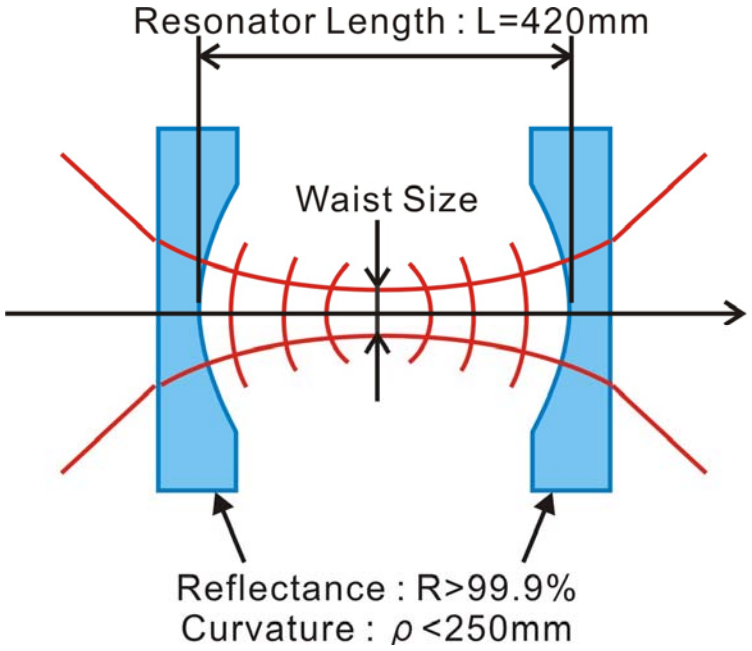
Beam Waist : 170um

⇨ Mirror Curvature : 250mm

Enhancement Factor : >1000

(Finesse : >3000)

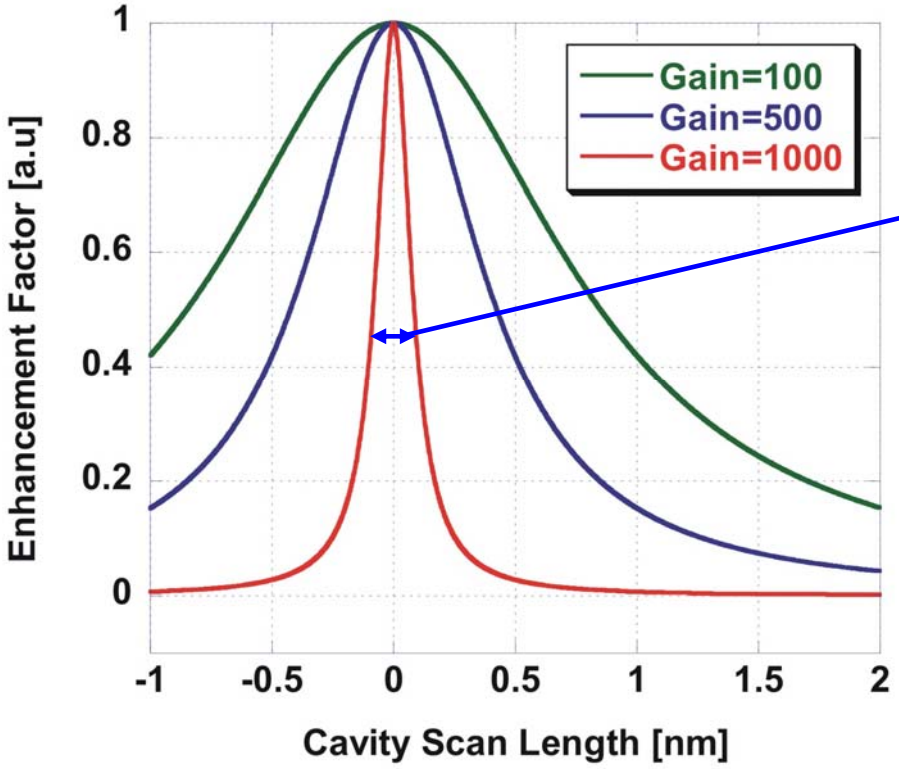
⇨ Mirror Reflectivity : >99.9%



At first, we develop the cavity finesse
to maximize the number of x-rays.

Optical Cavity R/D ~Problems of Optical Cavity~

Width of resonance peak



Enhancement factor=1000
Peak width (FWHM)=0.17nm

No jitter is permitted!!

Where are the jitters come from?

>Mode-locked laser FB

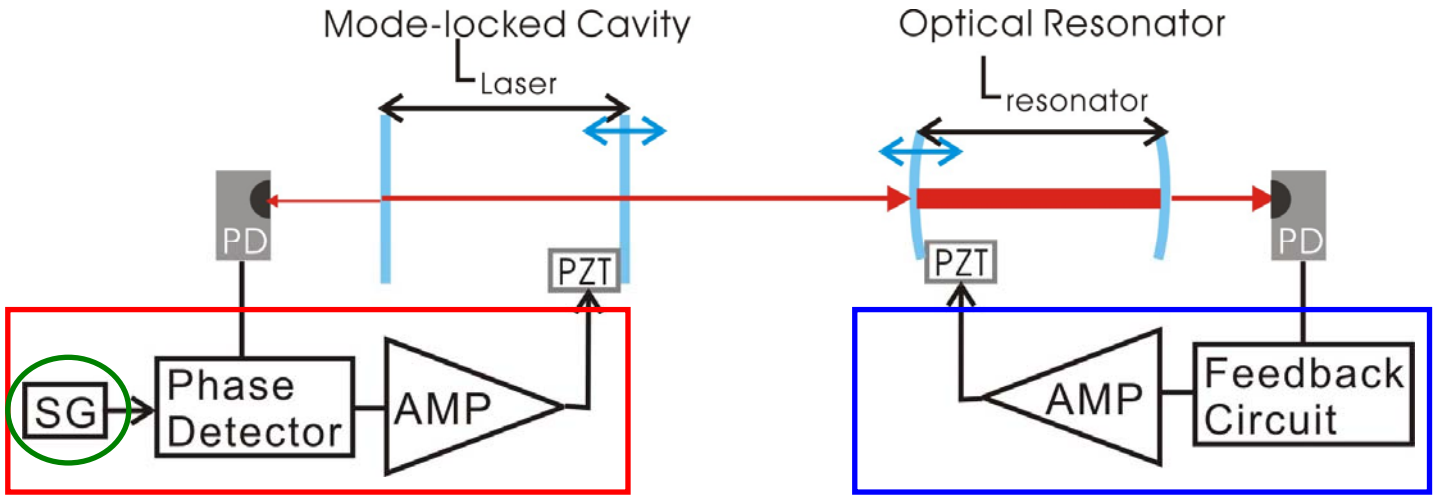
Timing stabilizer FB causes a jitter

>Acoustic noises

1~2kHz acoustic jitter appears

Optical Cavity R/D ~Mode-locked laser FB jitter~

Our setup consists of two-cavities, controlled by FB circuit.



Mode-locked laser PLL
(Phase Locked Loop)

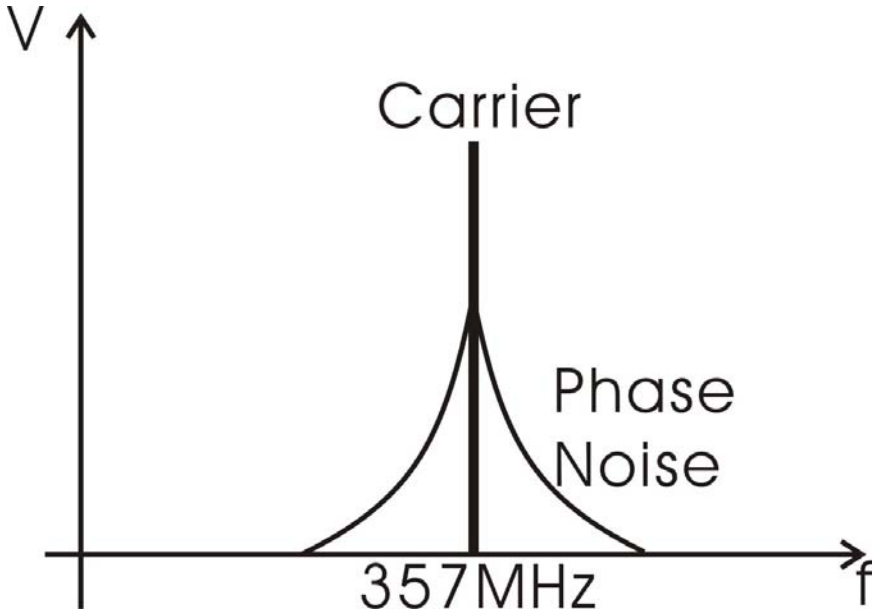
Resonator length is controlled by laser power in cavity to fix “on resonance”

We should adjust the both cavity length less than 0.1nm.

$$| L_{laser} - L_{cav} | << 0.17nm$$

Optical Cavity R/D ~Mode-locked laser FB jitter~

Mode-locked laser FB jitter source is “signal generator” that generates the reference signal of PLL.



Reference signal has small phase noise.

This noise must be **less than 0.1nm.**

↓

No SG is satisfied this condition.

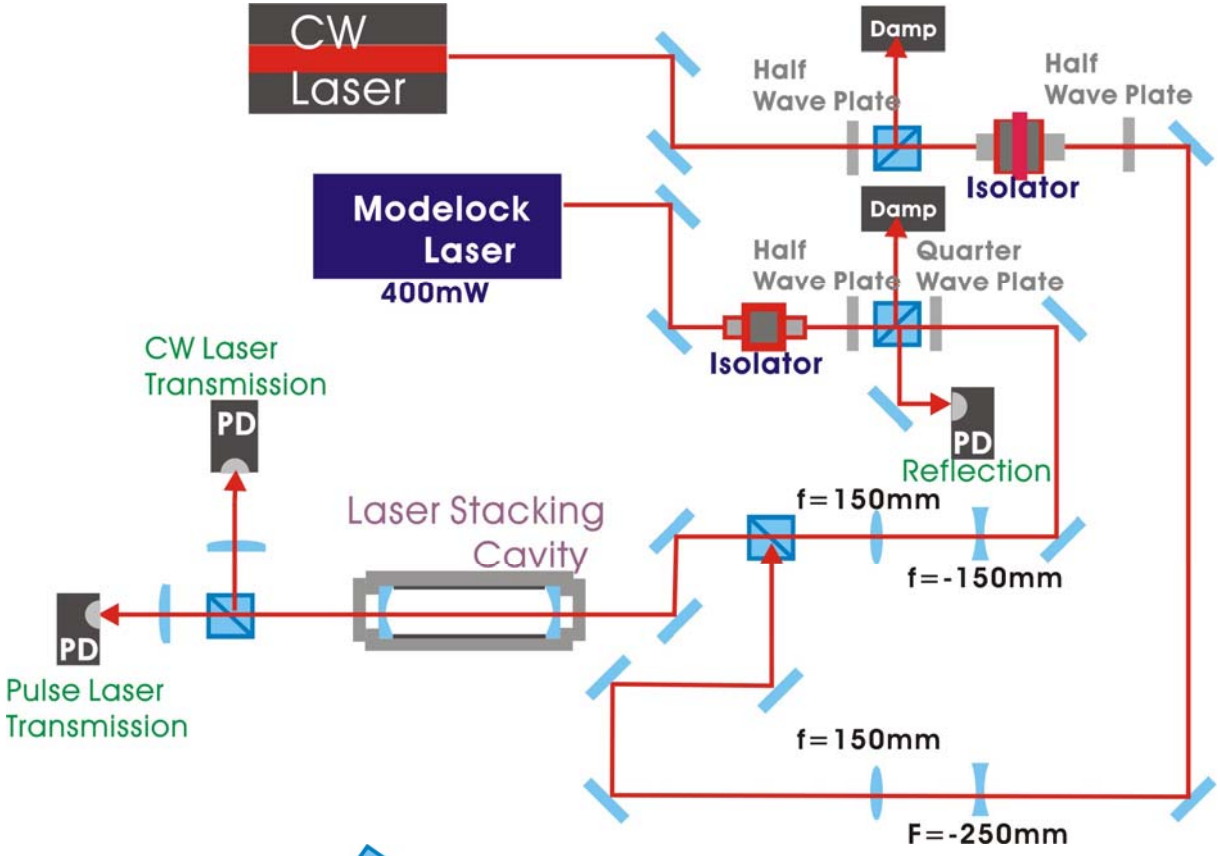
We made a feedback circuit to avoid the phase noises.

↓

We decreased the fast part of the phase noise.

Optical Cavity R/D ~Acoustic Noises~

Our experimental setup of pulse laser cavity test bench
This setup is suitable to determine the component
that is affected by acoustic noises.



<Feature of setup>

CW laser and pulse laser are stacking in resonator at the same time

Using CW laser ->oscillator is only a **solid crystal** ->Almost acoustic noise is not affective to the oscillator

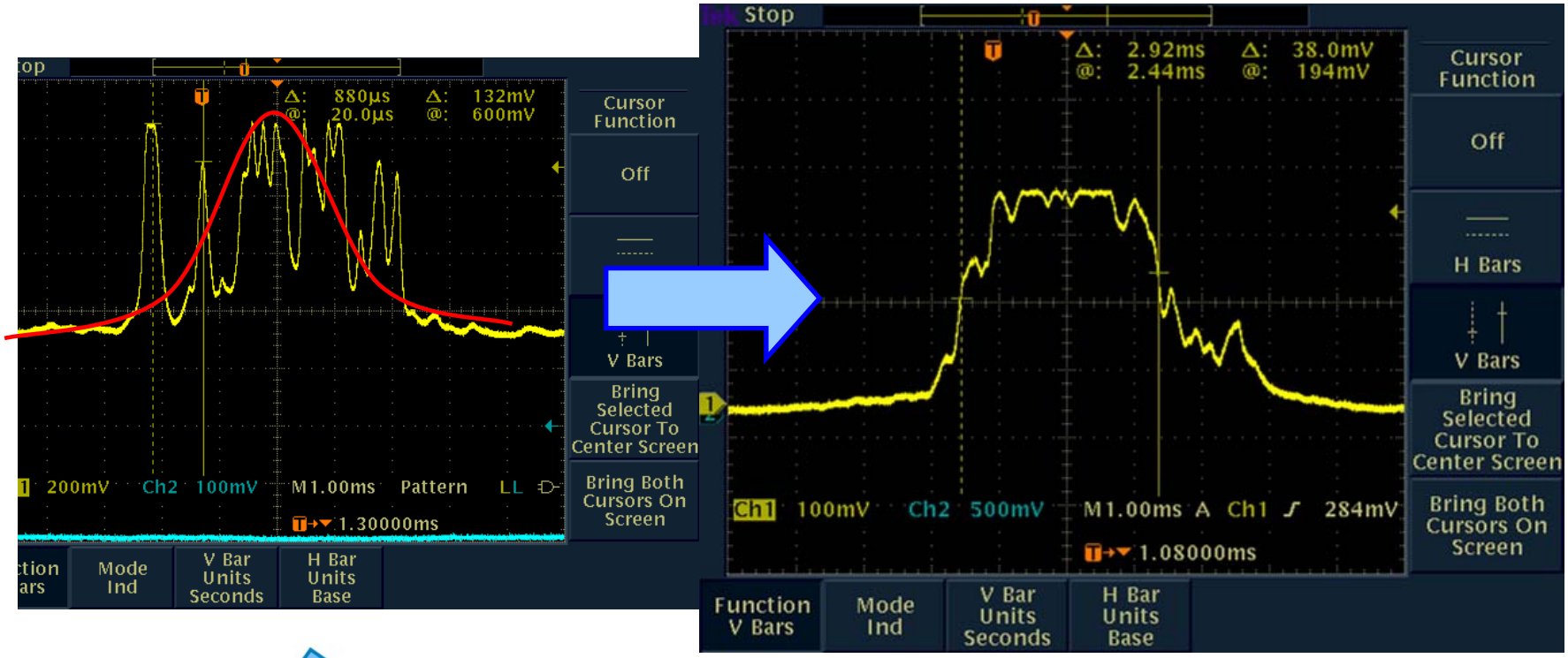
Optical Cavity R/D ~Acoustic Noises~

After determination of sources,

we make an effort to reduce acoustic noise jitters.

Ex) install dampers for high frequency jitter

soundproof materials

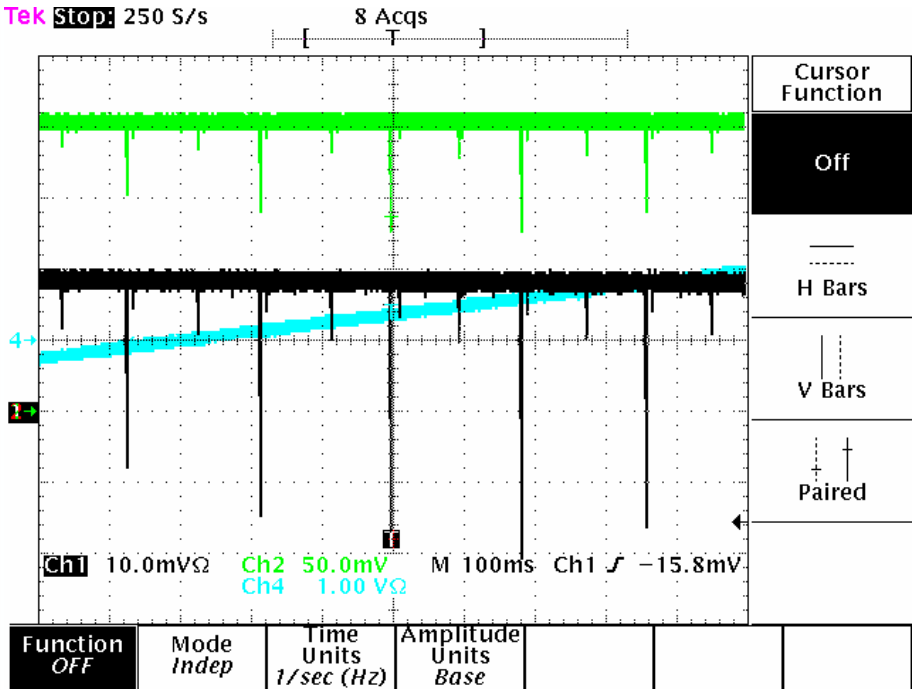


Optical Cavity R/D ~Current Status~

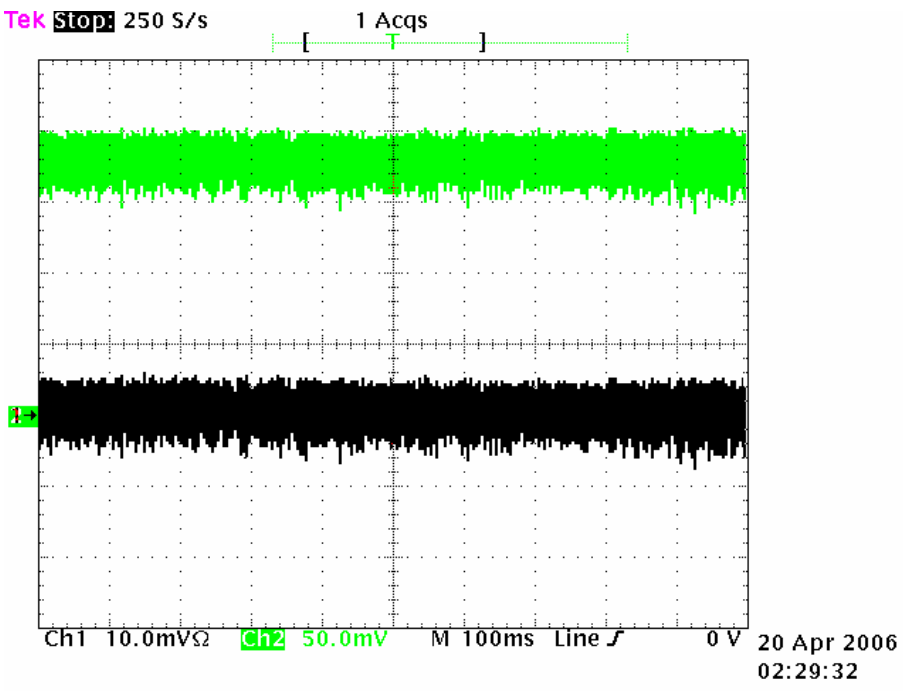
This is the current status of our optical cavity system.

Finesse : 3000~

Intensity Jitter with FB : 15%~ peak-peak



FB error signal



FB ON

Optical Cavity R/D ~Preparation of Install Cavity~

After several studies to characterize and reduce the jitters, we decide to install the cavity to LUCX accelerator.
The parameter of cavity is as follows.

Frequency Length	Finesse Reflectivity of mirror	Waist Size Curvature of mirror	Inject laser power	Laser power in cavity with FB
357MHz 420mm	~3000 ~99.9%	170um 250mm	6.8W @357MHz	Now measuring and developing

Conclusions

>We have developed the multi-bunch beam accelerator and pulse laser optical cavity for LUCX x-ray generation.

>100bunches/train high quality multi-bunch beam has been generated using Cs-Te photo-cathode rf-gun.

>We are studying about many jitter, to construct a stable pulse optical cavity system.

>Finesse ~3000 optical cavity will install in LUCX accelerator.

>In this summer, we will make collision and generate X-rays.