Optical Cavity R&D around KEK-ATF

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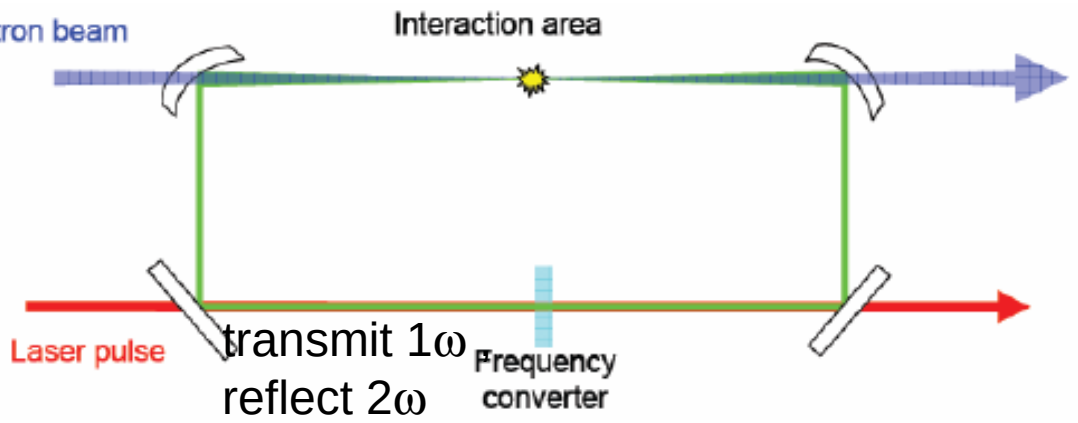
Hiroshima Univ.

Nov. 2008
LCWS08
at Chicago

Ideas to reduce laser power

- RING (Recirculation Injection by Nonlinear Gating) Cavity (Gronberg LEI2007)

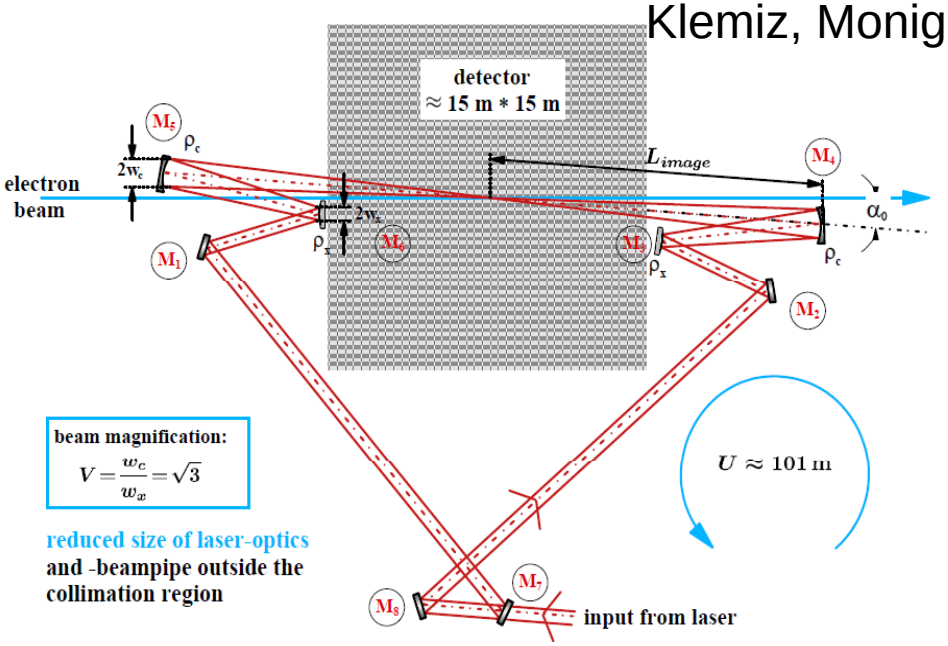
Recirculation of a laser pulse
to reduce average laser power



- Pulse Stacking Cavity

Klemiz, Monig

Stack laser pulses on phase
to reduce peak as well as average power

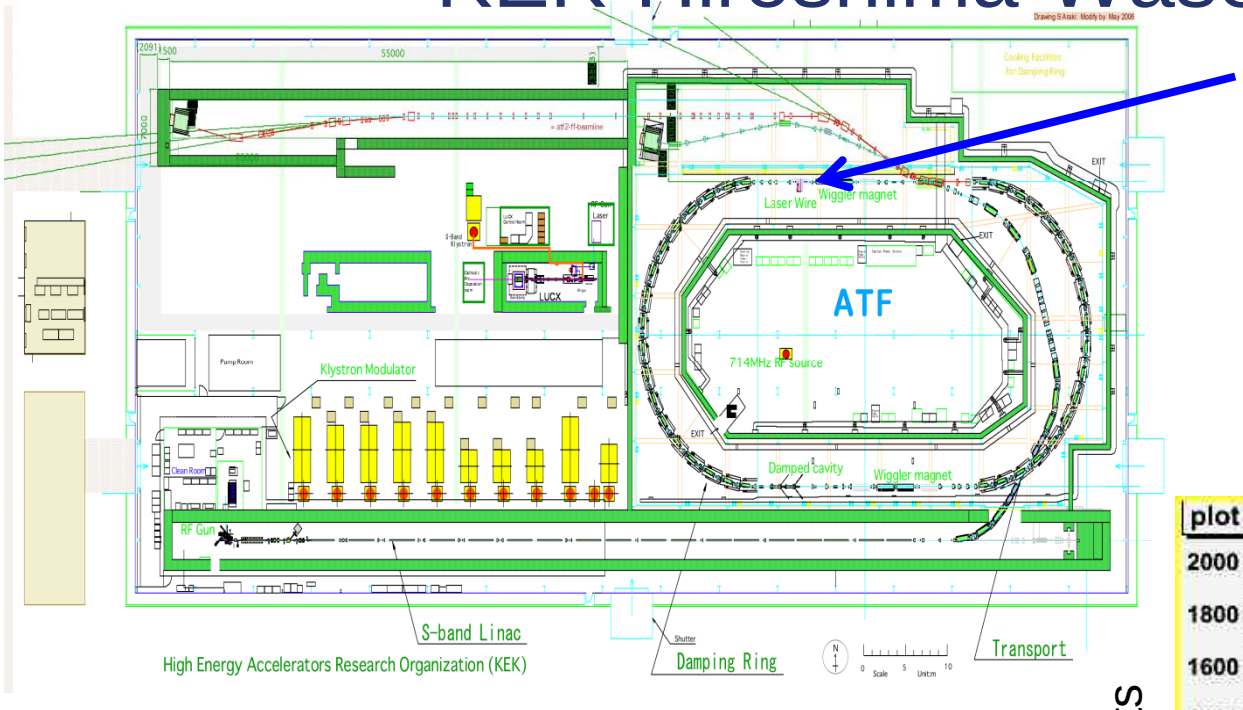


Optical Cavity R&D around ATF

- O(10MeV) γs for Compton Based Polarized Positron source.
- Hard X ray (~30keV) sources
  - **LUCX project**
- New 5 year project
  - **Compact X ray source w/ SRF electron accelerator and pulse stacking cavity.**

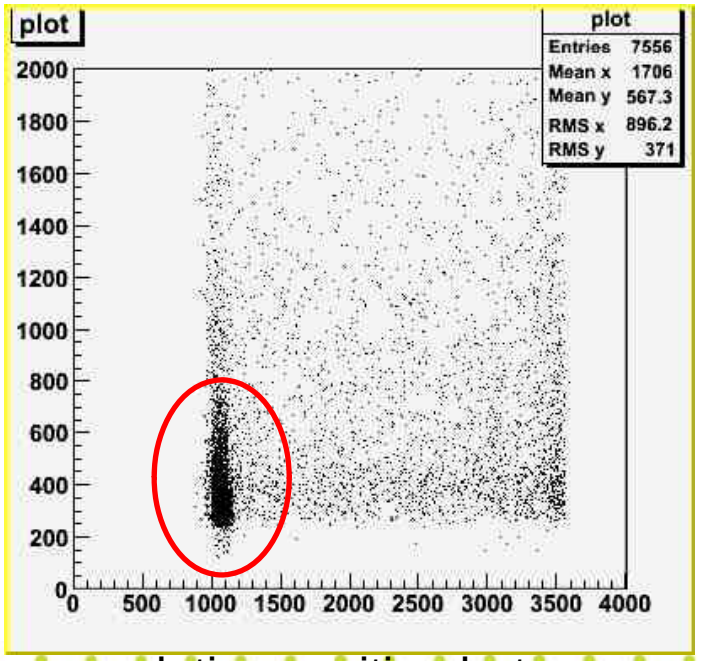
Accumulating technique and experiences w/ cavity and accelerators.
Ring cavities are being planned as next step

PosiPol for LCs
KEK-Hiroshima-Waseda-Kyoto

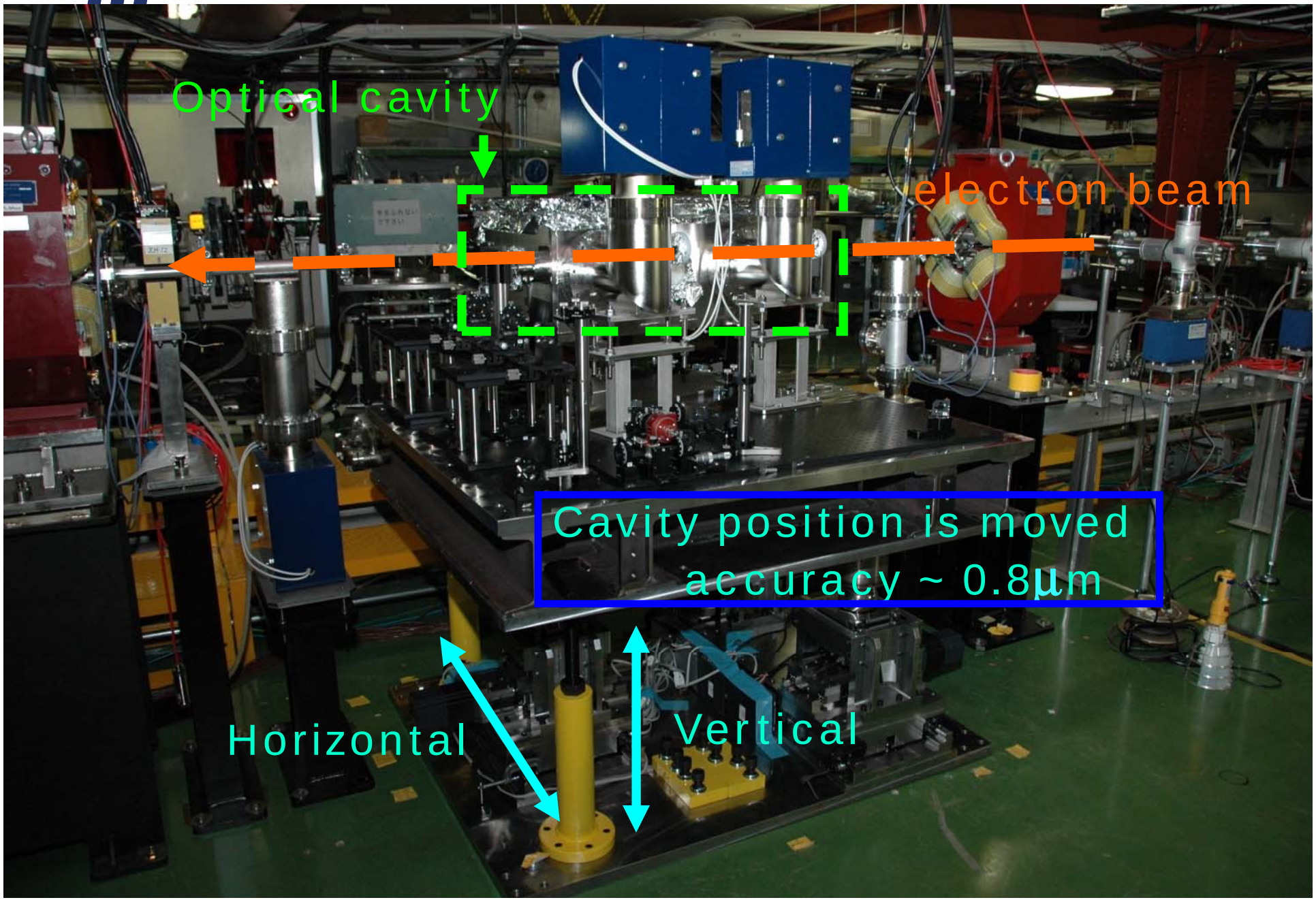


Enhansement of ~ 250 achived
(consistent w/ mirror reflectivity)

next step → to get stable high intensity γs



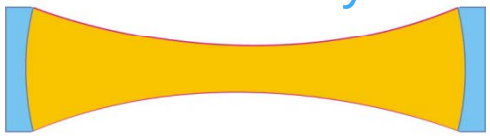
Set up at KEK-ATF



The appearance of light resonance signal

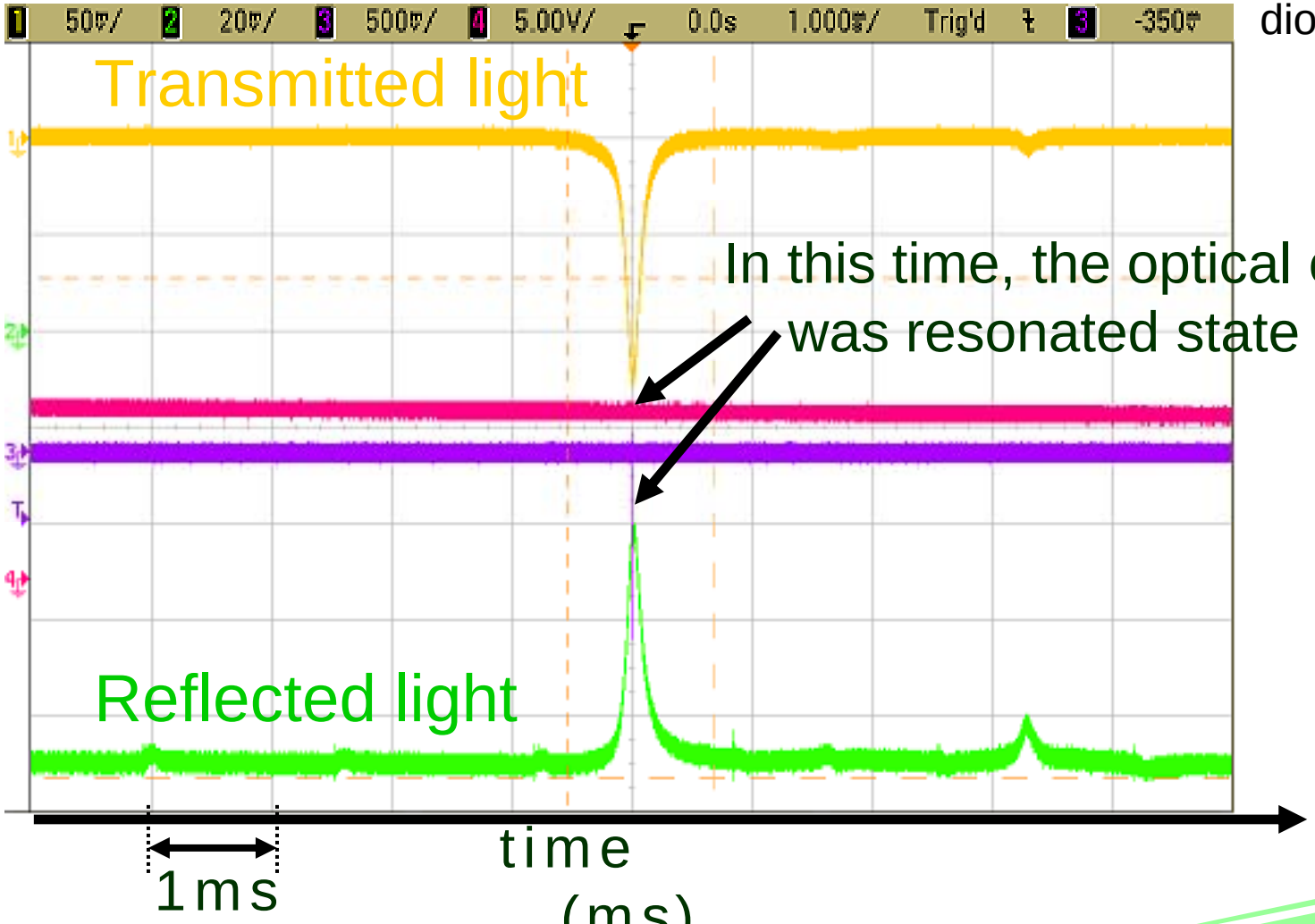
Mirror reflectivity : 99.6%

Mode locked laser



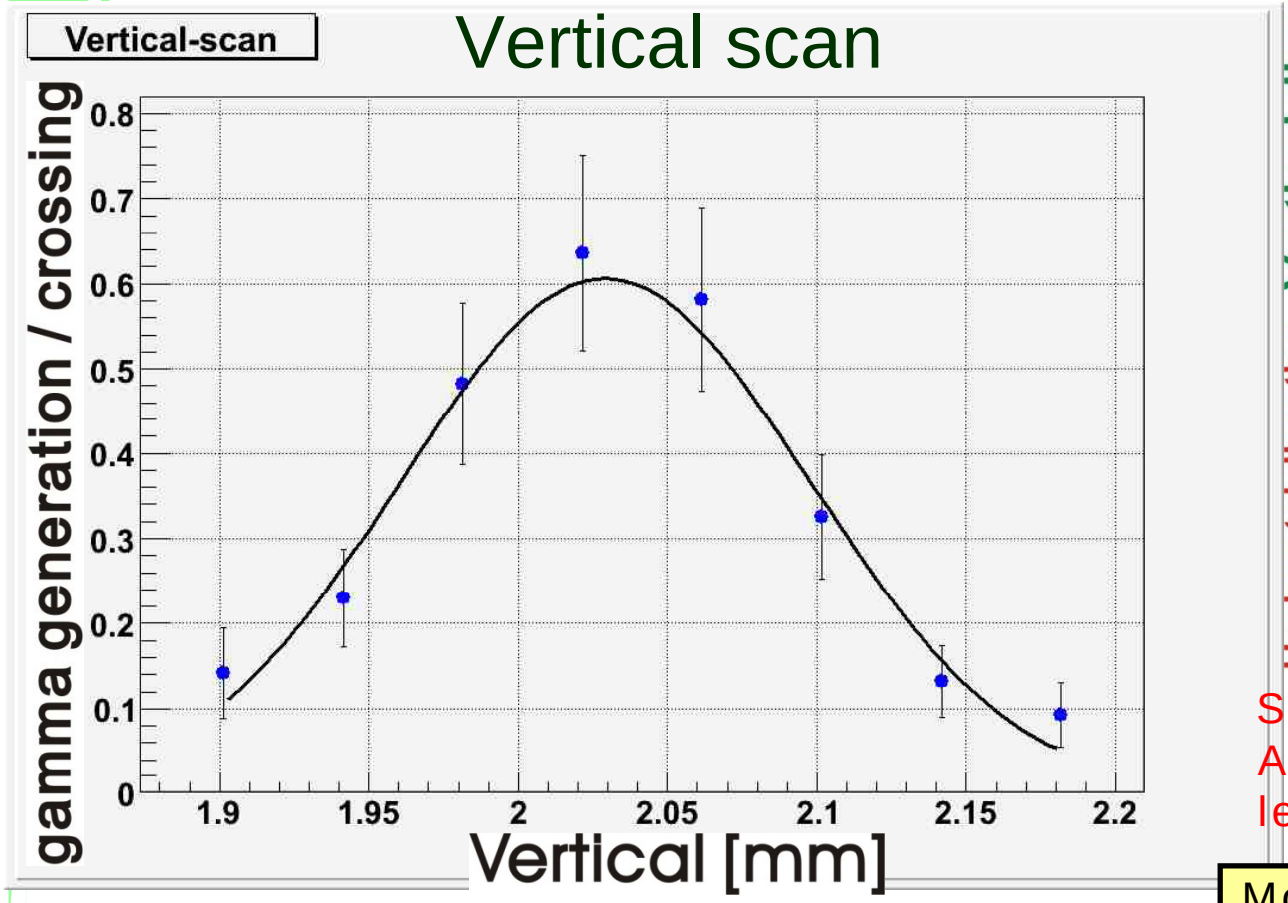
Transmitted light

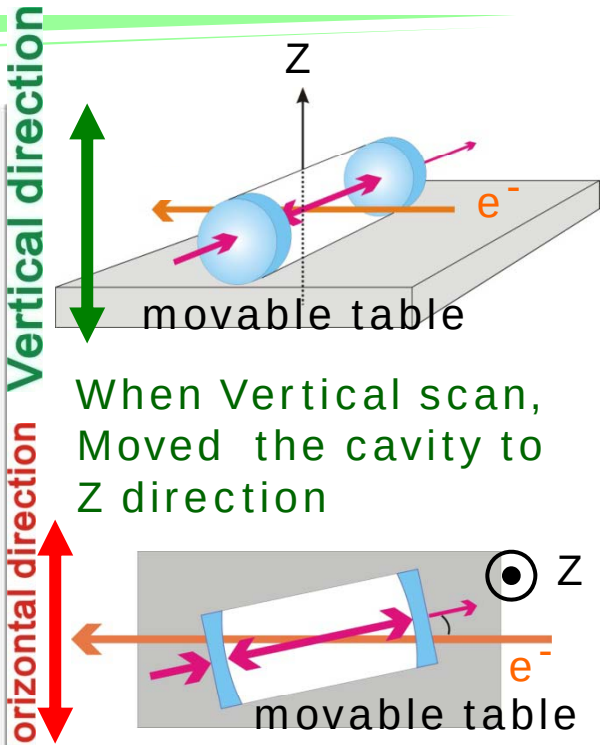
PD (Photo diode)



Continued to change the length of the external cavity.

Procedure of measurement 1





Moved accuracy ~ 0.8μm

① Vertical scan

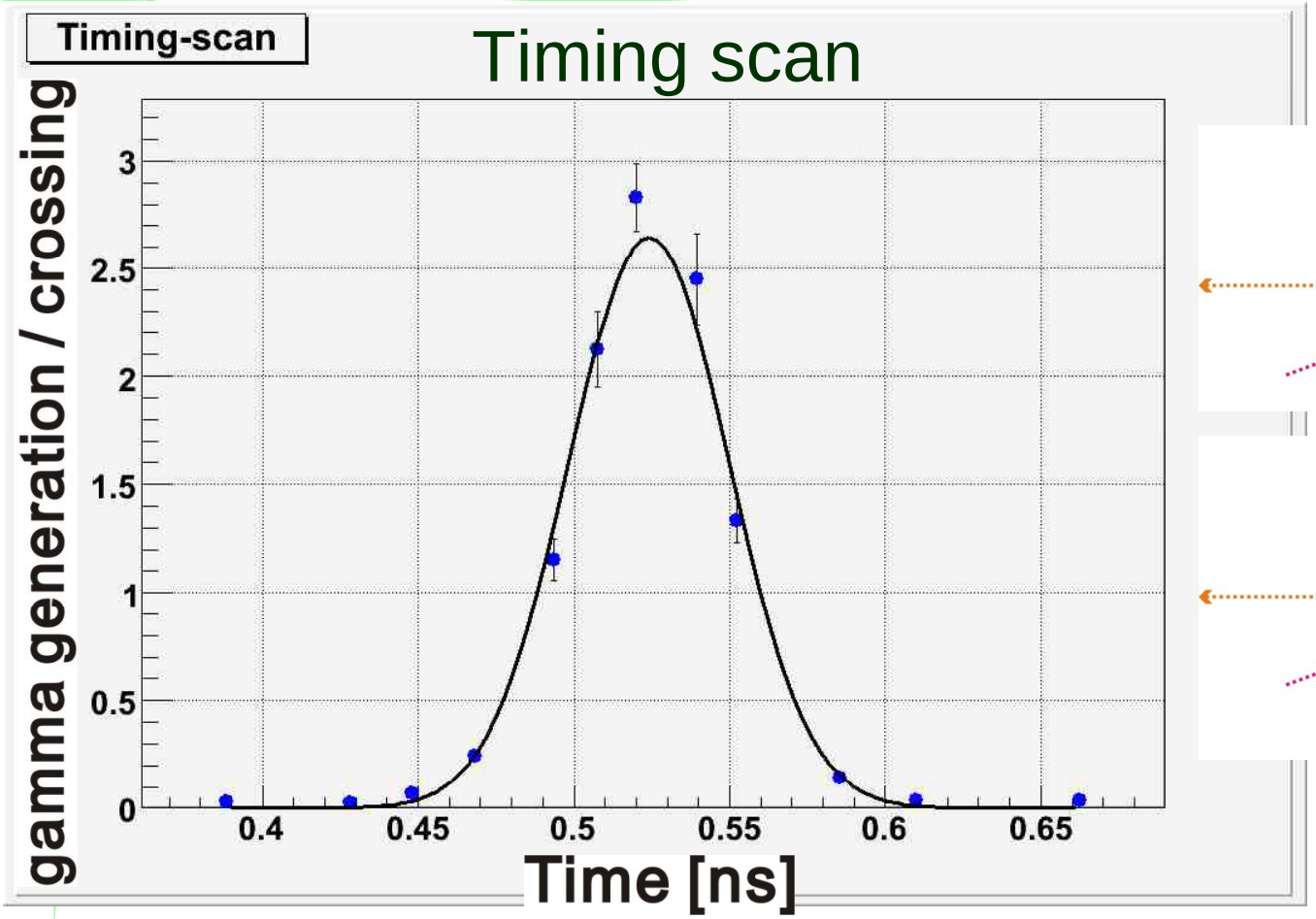
Scanning to the laser vertical position and find the best position to observe gamma

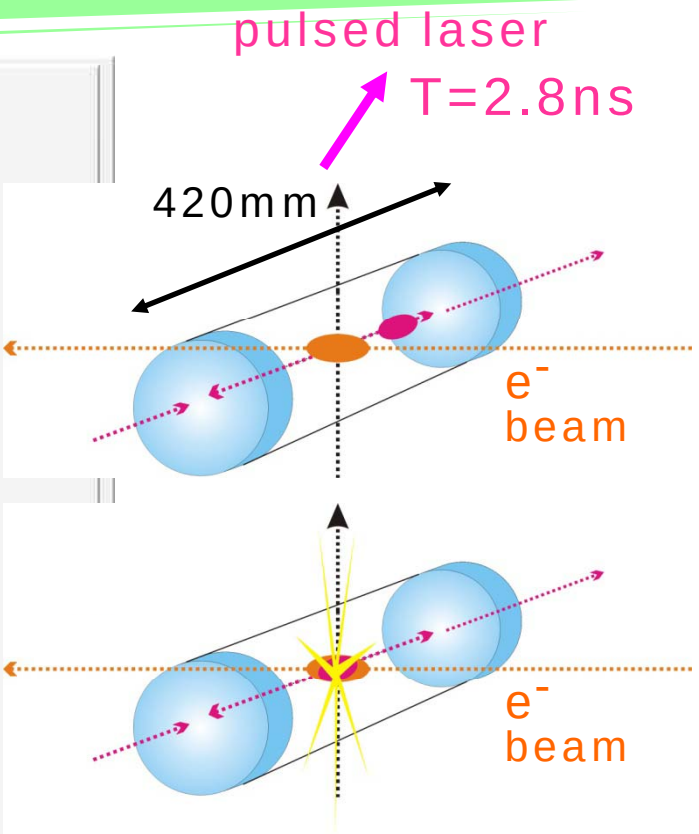
② Horizontal scan

Vertical was fixed to the best position.

Scanning to the Horizontal.

Procedure of measurement 2





③ Timing scan

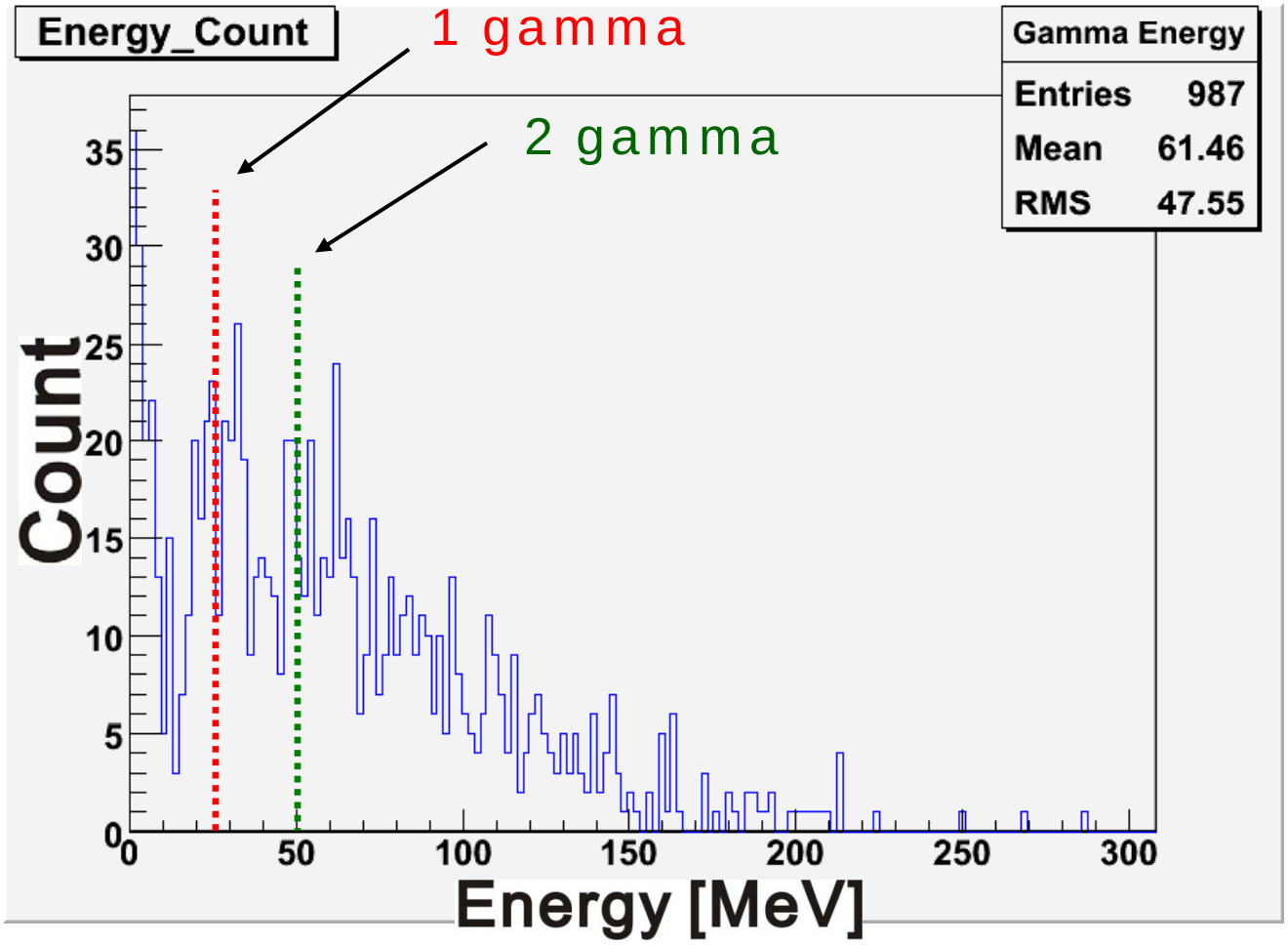
Vertical and Horizontal were fixed to the best position.

And turned on the switch of phase locked loop .

After that scanning phase.

We found the best collision point

Gamma Energy distribution 2



This graph shows the appearance of gamma energy distribution.

one of gamma had 16~28 MeV energy.

The number of gamma

date	bunch	the number of electron	transmitted power	stack power estimate	γ
		1/ pulse (included in one train)	W	W	
2008/ 4/ 22	20	2.6E+10 (in 20 bunches)	1.55	388	3.1
2008/ 5/ 27	1	7.2E+9 (in 1 bunch)	1.09	272	3.27

Mirror reflectivity : 99.6% ⟶ stack power = $\frac{\text{transmitted power}}{1 - 0.996}$

bunch distance : 2.8 ns

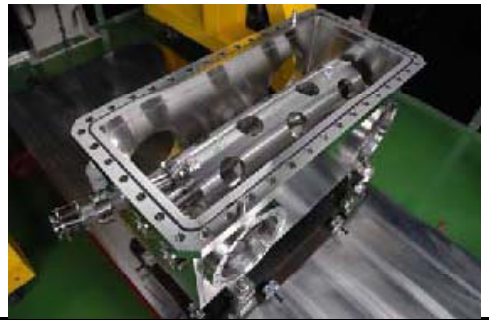
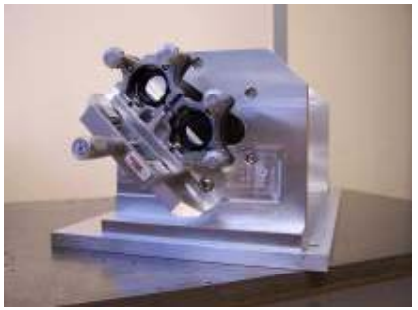
We estimated the number of gamma to use a simulation software “CAIN”.

20 bunches :	experiment	γ~3.1	simulated by CAIN γ ~ 20
1 bunch :	experiment	γ~3.3	simulated by CAIN γ ~ 4.5

In the case of 1 bunch, the number of gamma seems to consist comparing our experiment data with estimate by CAIN.

However, the data of 20bunches were inconsistent.The reason of this,there was a possibility that not every electron bunches were collided.

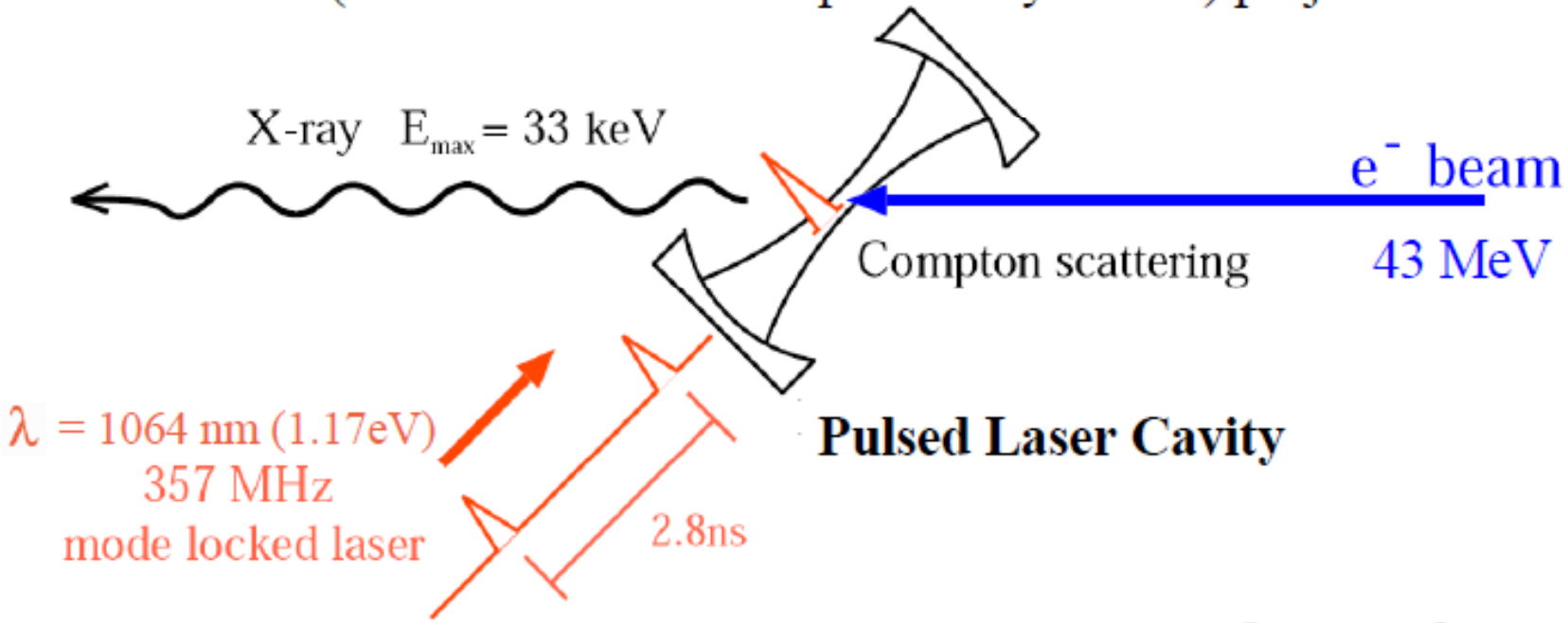
Next plan: 4 mirror ring cavity

	KEK	LAL
		
type	2 mirrors FP	4 mirrors ring
enhancement	1000	10000
Laser spot size	30μm	15μm
Feed back	Analog PID	digital
e-	at ATF, to get experiences with e-beam	stand alone (new w/ e- beam being designed. to be at ATF 2009)

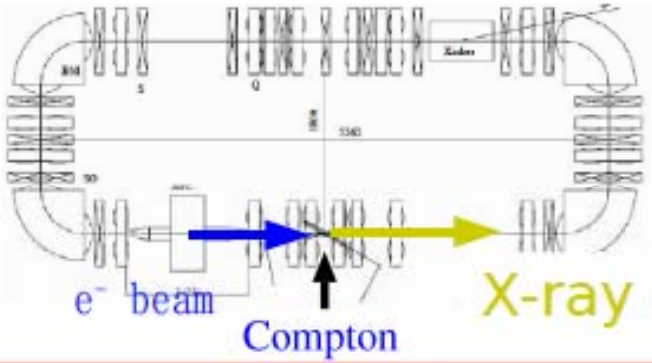
Introduction

Fukuda
PosiPol2008

We have developed an X-ray source based on Inverse Compton Scattering with the pulsed laser-wire Cavity.
=> LUCX(Laser Undulator Compact X-ray source) project.



Final layout of high intensity X-ray source

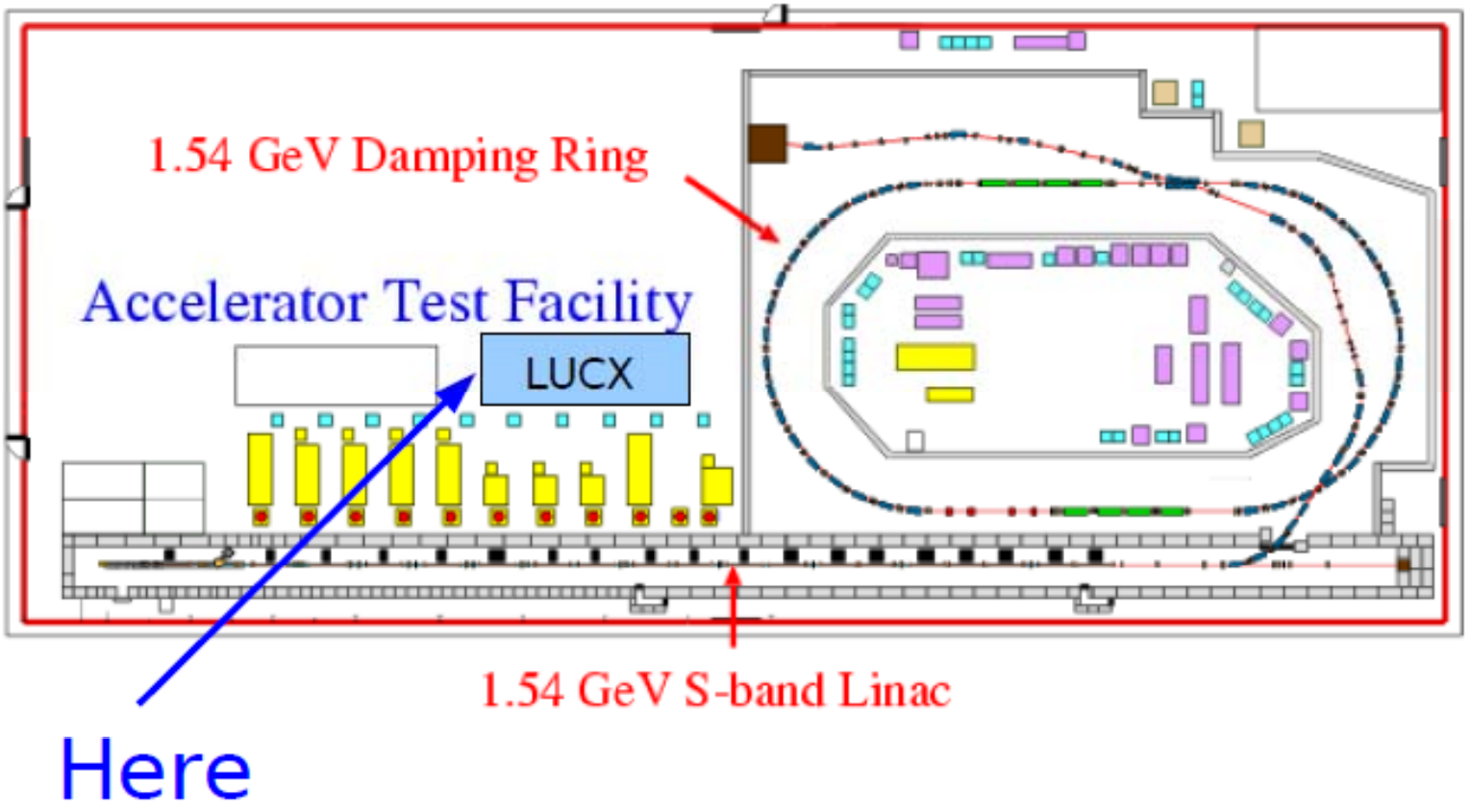


Compact Storage Ring

Place of LUCX

Fukuda
PosiPol2008

The accelerator for LUCX project is constructed in ATF building



Pulsed Laser Cavity

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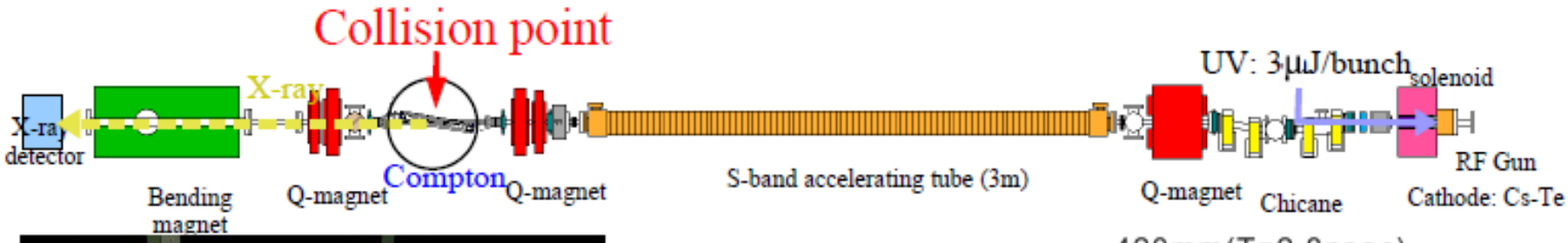
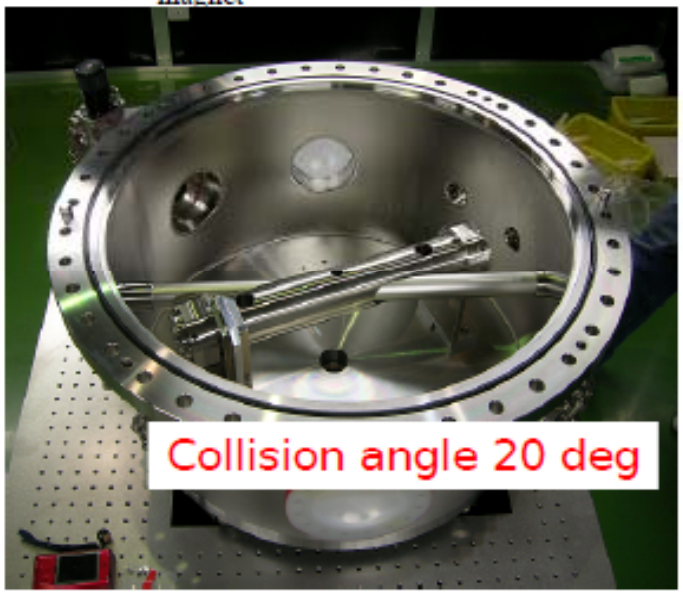
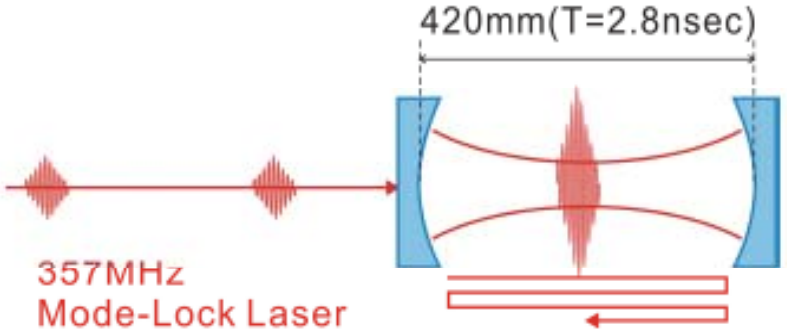
PosiPol2008

The pulsed laser cavity is installed at the collision point.







$$L_{cav} = n\lambda / 2$$

$$L_{cav} = mL_{laser}$$

Pulsed Laser cavity chamber

Burst mode Operation

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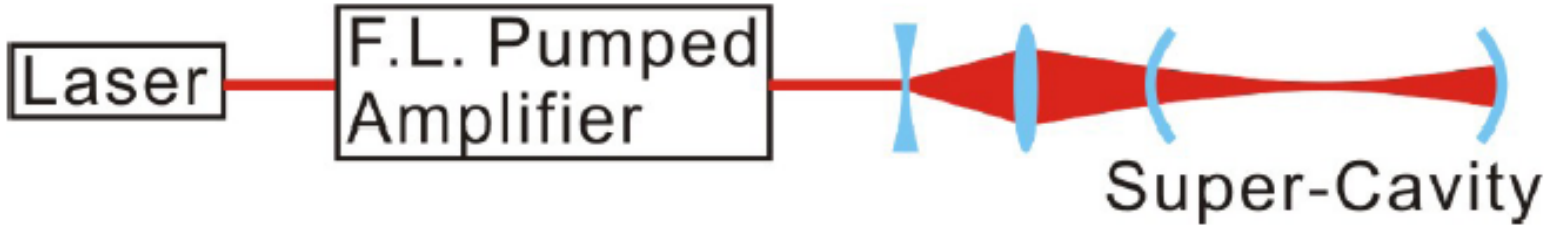
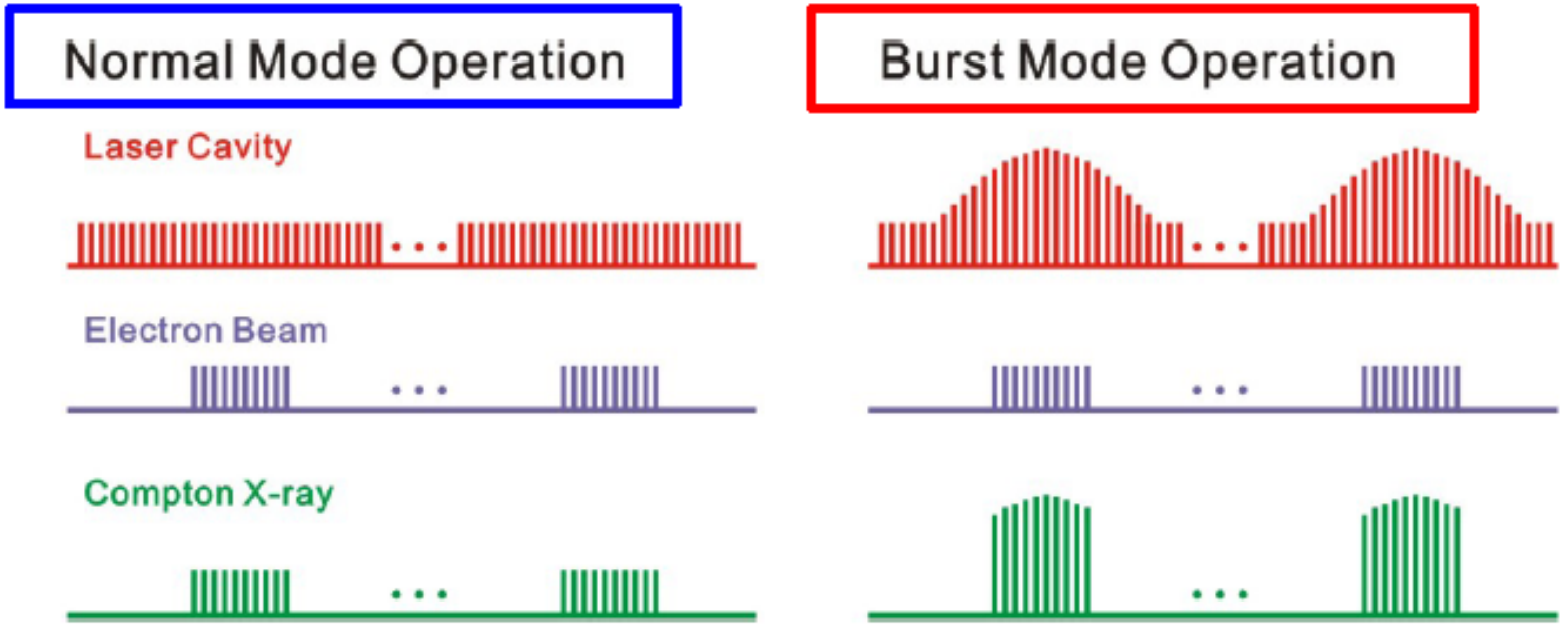
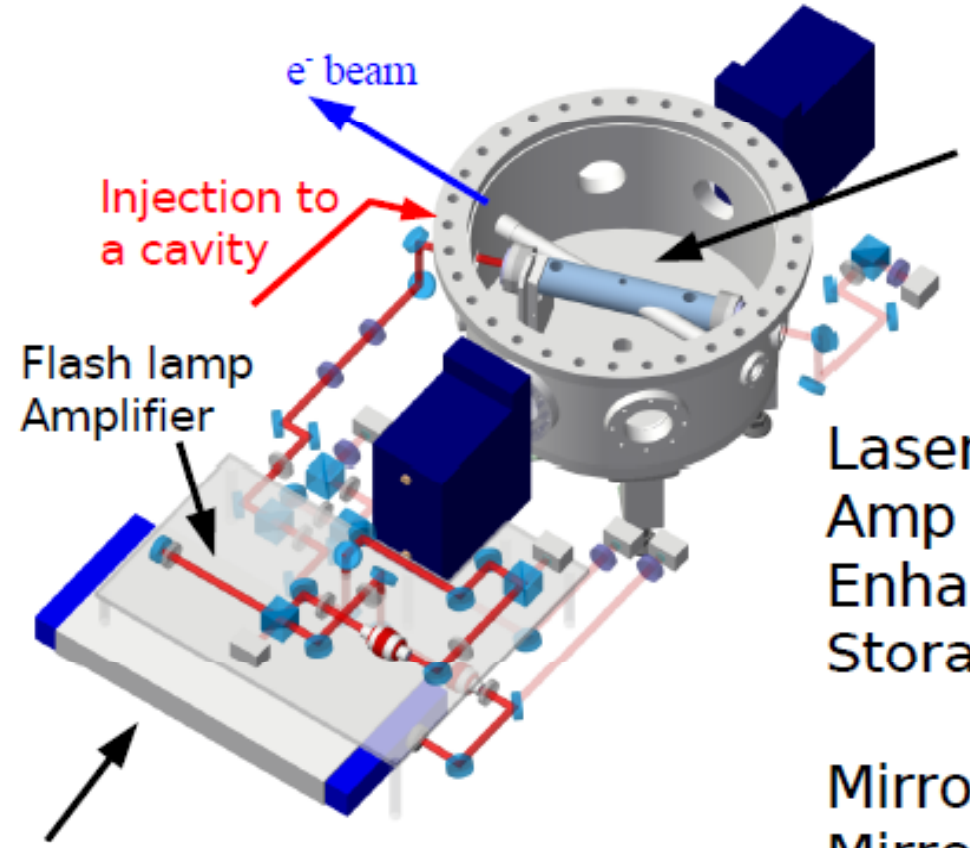
PosiPol2008

In order to increase the number of x-rays,
A flash amplifier is installed before the laser cavity.





Burst mode cavity parameters



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Laser power	2.5 W
Amp gain (2 pass)	80
Enhancement factor	200
Storage peak power	**40 kW**
	112 uJ/pulse
Mirror curvature	210.5mm
Mirror Reflectivity	99.6%
Waist size	**30.3 um**
Finesse	878.5
Cavity length	420 mm
Pulse length (FWHM)	7ps

Expected number of X-rays

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PosiPol2008

	Laser (in Cavity)	e^- beam
Energy	λ = 1064 nm (1.17eV)	40 MeV
Intensity	112μJ/bunch	0.4nC/bunch
	3.0×10^{14} photons/bunch	2.5×10^9/bunch
Beam size	σ = 30 μm	σ_x, σ_y = 80μm, 40μm
Pulse width	7ps	10ps
Number of bunch		100 bunches/train

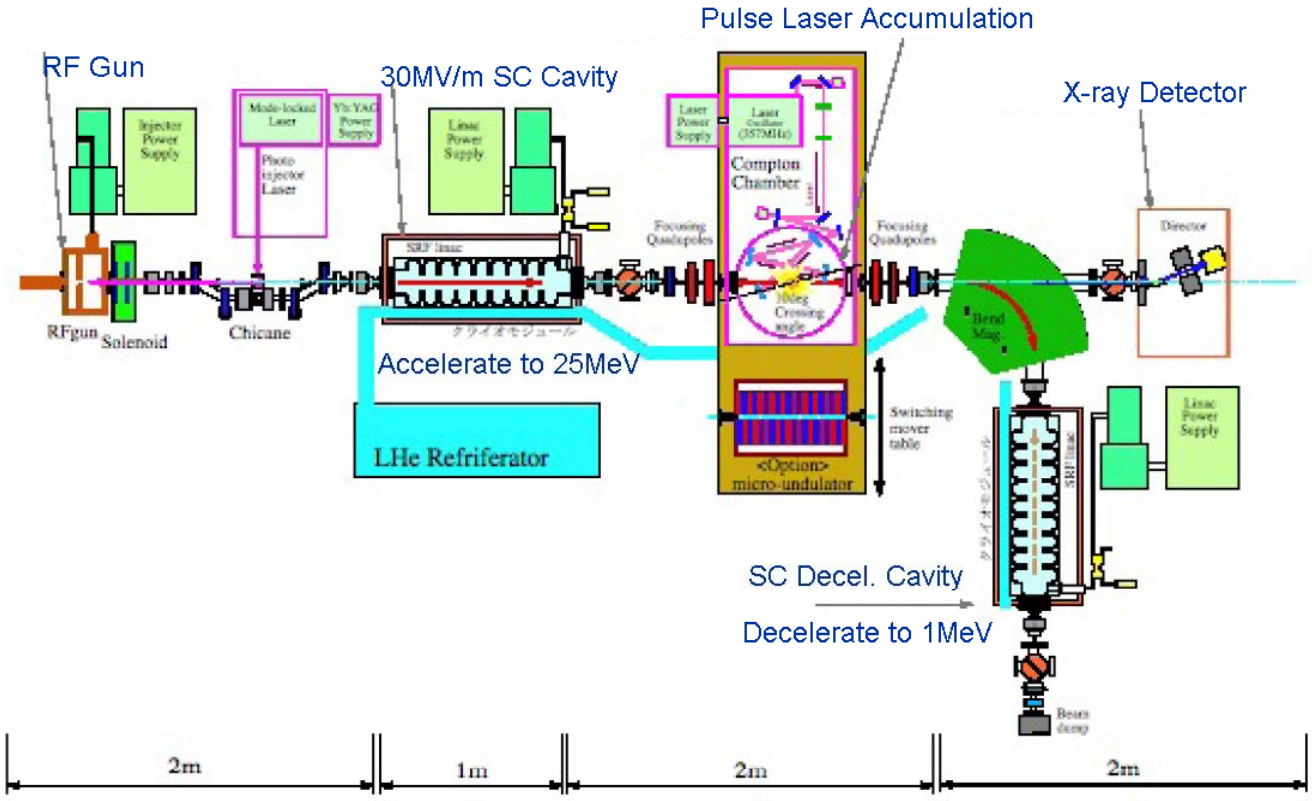
Measured number of X-rays is 247photons/train/2.17mrad.
(Total: 1.5x10^4 photons/train)

Expected number of X-rays is 798 photons/train/2.17mrad.
(Total: 4.8x10^4 photons/train)

However, it is larger by factor of 3 than the experimental results.

量子ビーム
（Ryoushi Biimu, Quantum Beam） Project

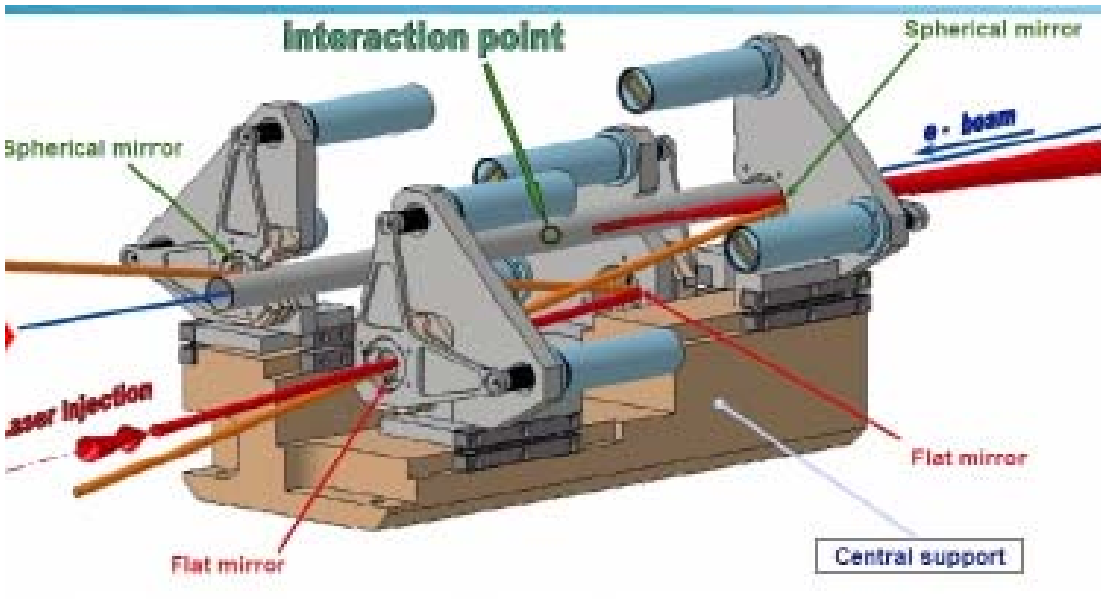
High-Intensity Compact X-ray Source



- Must be demonstrated by JFY2012
- Includes 25 MV SC acceleration and deceleration (but perhaps, deceleration can be omitted)
- Beam current (9mA) and pulse length (1ms) same as ILC, but bunch spacing 6.15nsec

Laser pulse Stacking cavity

4 mirror ring cavity



Goal ; 50mJ/pulse
Waist 8μm

to be demonstrated by JFY2012

Summary

- **photon generation by Laser pulse stacking cavity / accelerator has been demonstrated both for**
  - **Polarized electron source (PosiPol)**
  - **hard x ray generation (LUCX)**
- **All projects going to 4 mirror ring cavity**
  - **PosiPol**
    - to be installed in 2009 by collaboration w/ LAL
  - **LUCX**
    - **going to be S-LUCX ?**
  - **Quantum beam project**
    - **4 mirror cavity w/ SRF LINAC**

Hope basic technology including implementation with accelerator is established in next a few years.