

Status of g ray generation at KEK-ATF

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for

French Labs. : LAL (Orsay) in Collaboration with
CELIA (Laser lab., Bordeaux) and
LMA (mirror coatings Lab., Lyon)

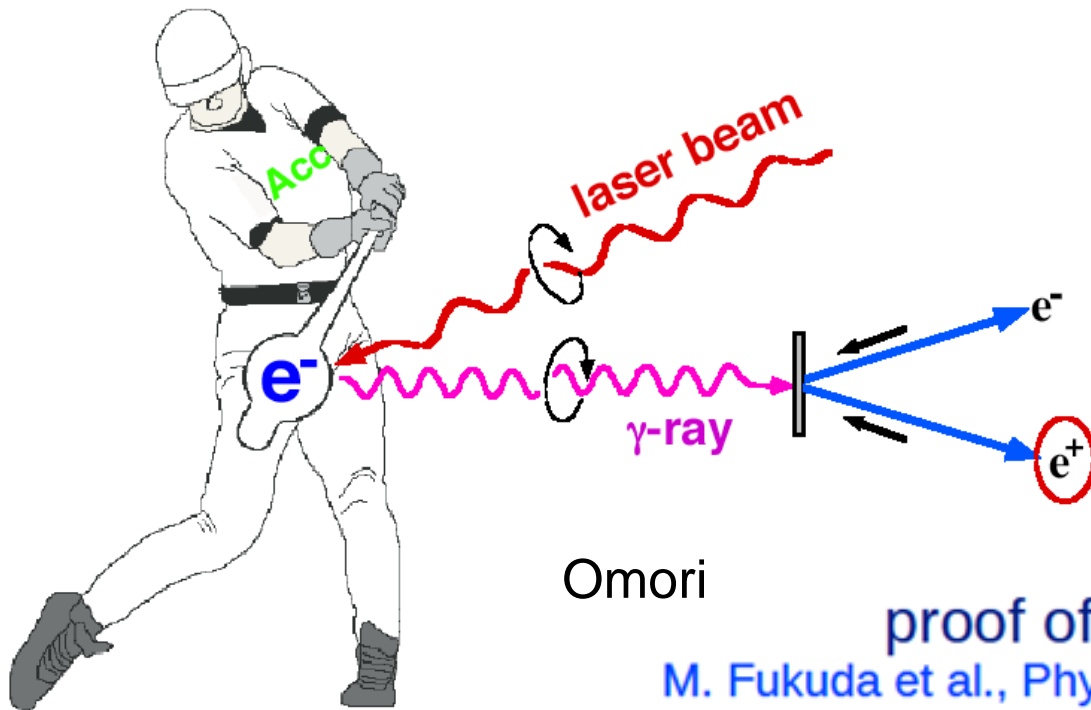
Japanese Labs. : KEK, ATF group,
Hiroshima University

- ▶ Introduction
- ▶ Status of the cavity R&D
- ▶ Out Look

06 September 2012
POSIPOL 2012

Introduction

► Polarized e^+ by laser Compton Scheme



$E_{e^-} \sim 1 \text{ GeV}$ for 10 MeV gammas
easy to control polarization

Omori

proof of principle experiment

M. Fukuda et al., Physical Review Letters 91, 164801 (2003)

T. Omori et al., Physical Review Letters 96, 114801 (2006)

Toward the positron sources

-> increase intensity of gamma rays

Staking Laser Pulses in Optical Cavity

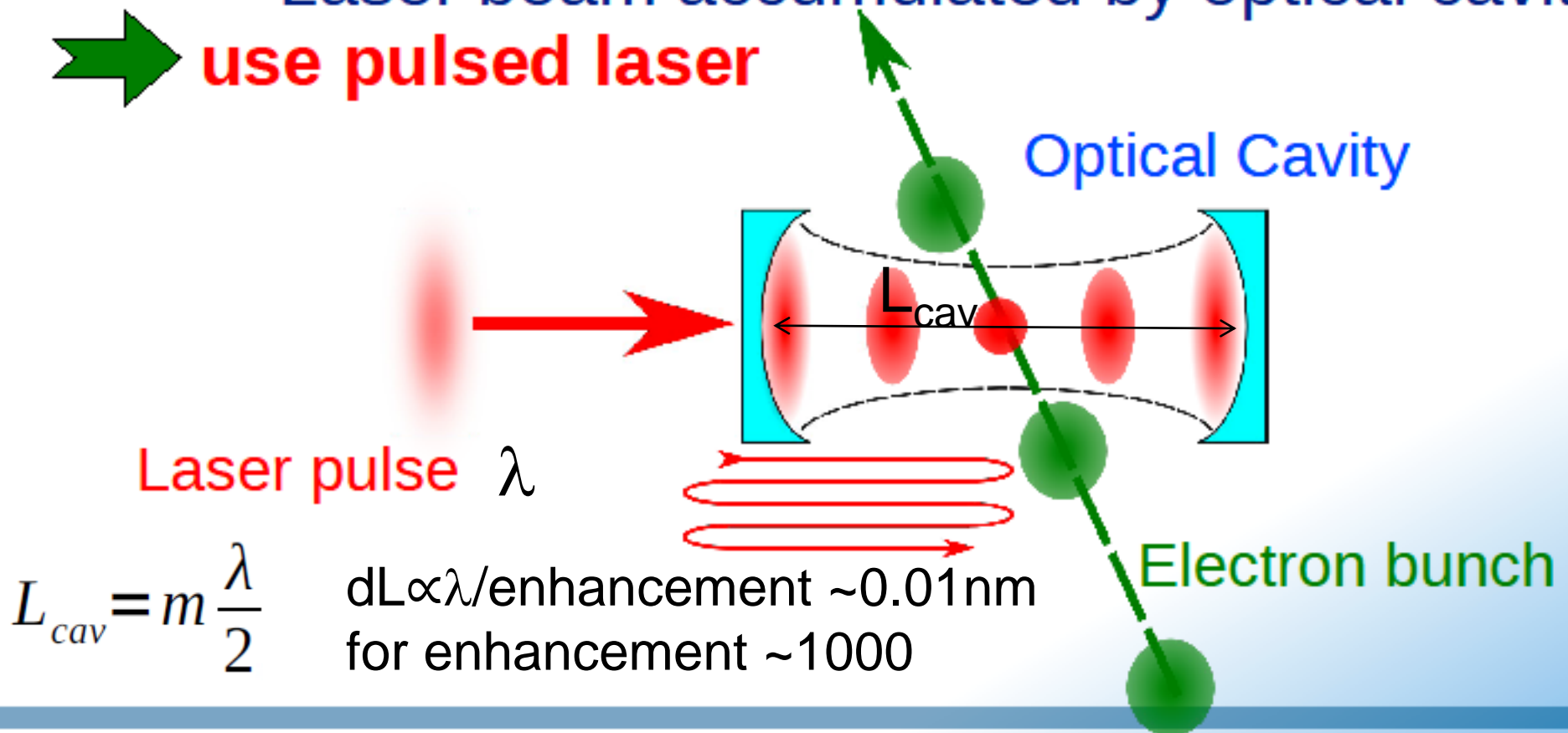
Miyoshi PosiPol2010

Increase power of laser beam at interaction point for increasing gamma yield.

➔ **enhancement with optical cavity**

Laser beam accumulated by optical cavity

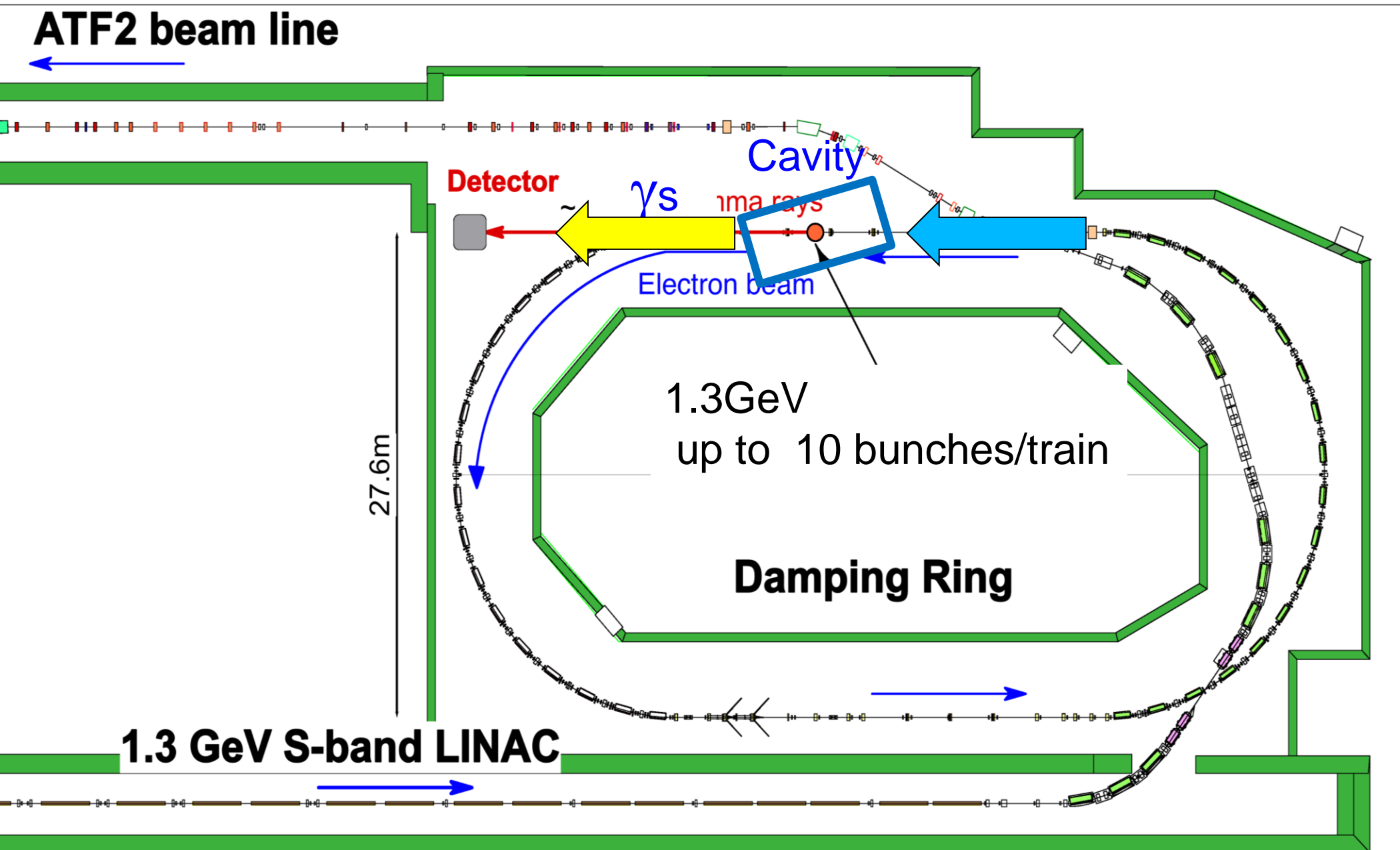
➔ **use pulsed laser**



$$L_{cav} = m \frac{\lambda}{2}$$

$dL \propto \lambda / \text{enhancement} \sim 0.01 \text{ nm}$
for enhancement ~ 1000

Experiments at the KEK ATF

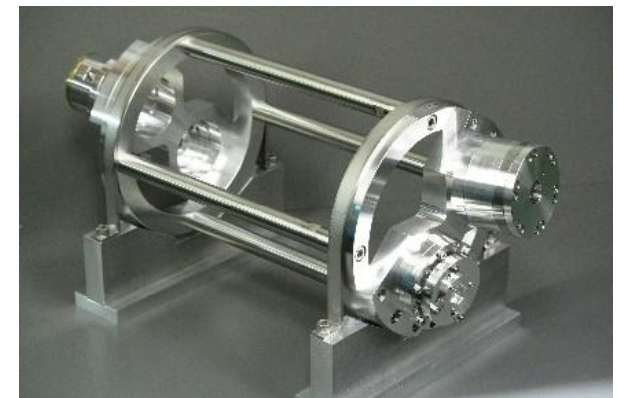
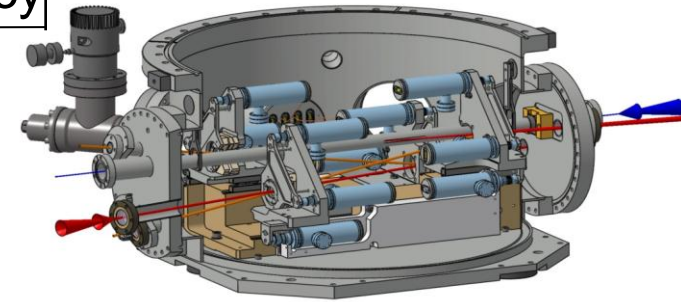


Brief History

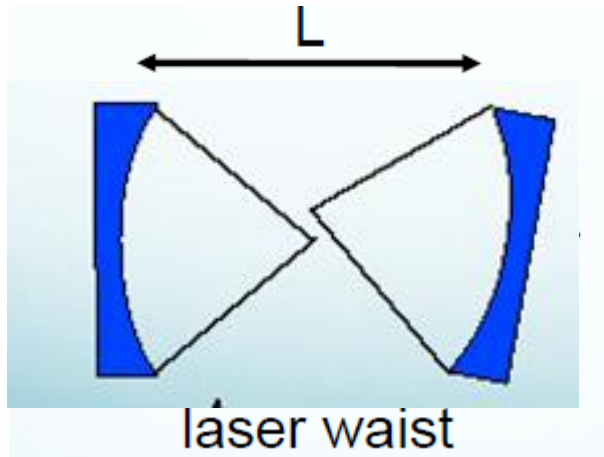
- ▶ 2007 2 Mirror cavities installed
 - 2.5kW γ rays generate
- ▶ 2010 French 4 Mirror cavity installed

Reported FJPPL2010 Annecy

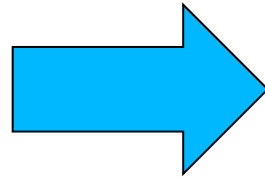
- γ rays confirmed
- ▶ 2011 earthquake
 - No major damage to our equipment.
 - beam back in June 2011
- ▶ 2011 KEK-Hiroshima 4 mirror cavity installed
 - γ rays confirmed



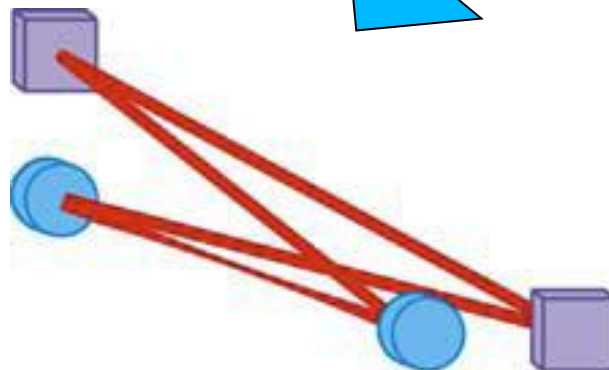
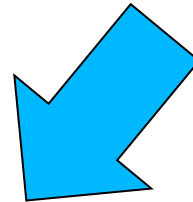
We should go to 3D 4 mirror ring cavity to get small spot size



2 mirrors is not stable for small spot size



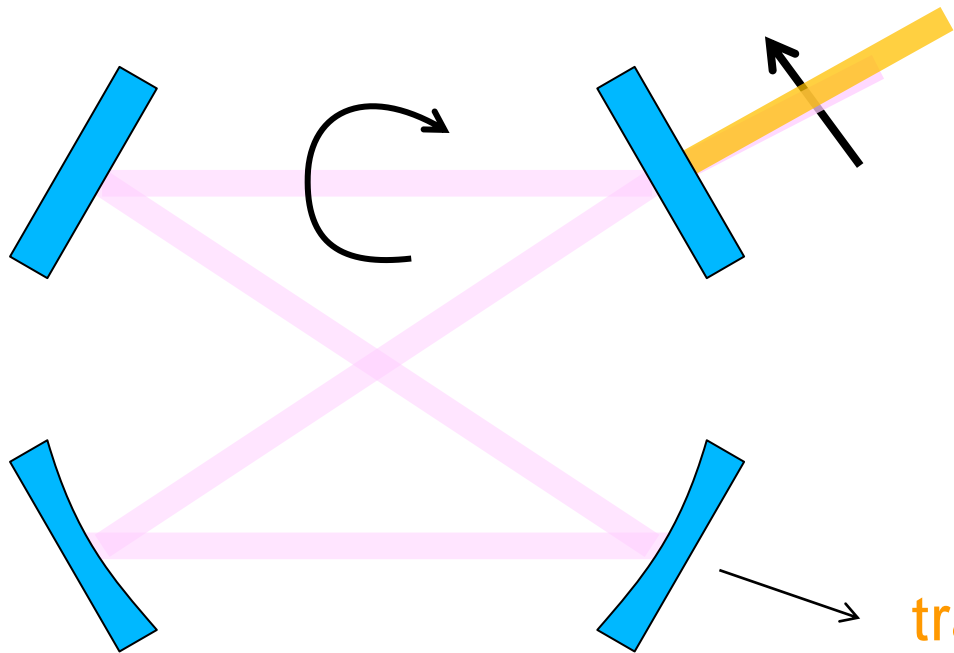
2d 4M has astigmatism



3D (or twisted)
4M ring cavity

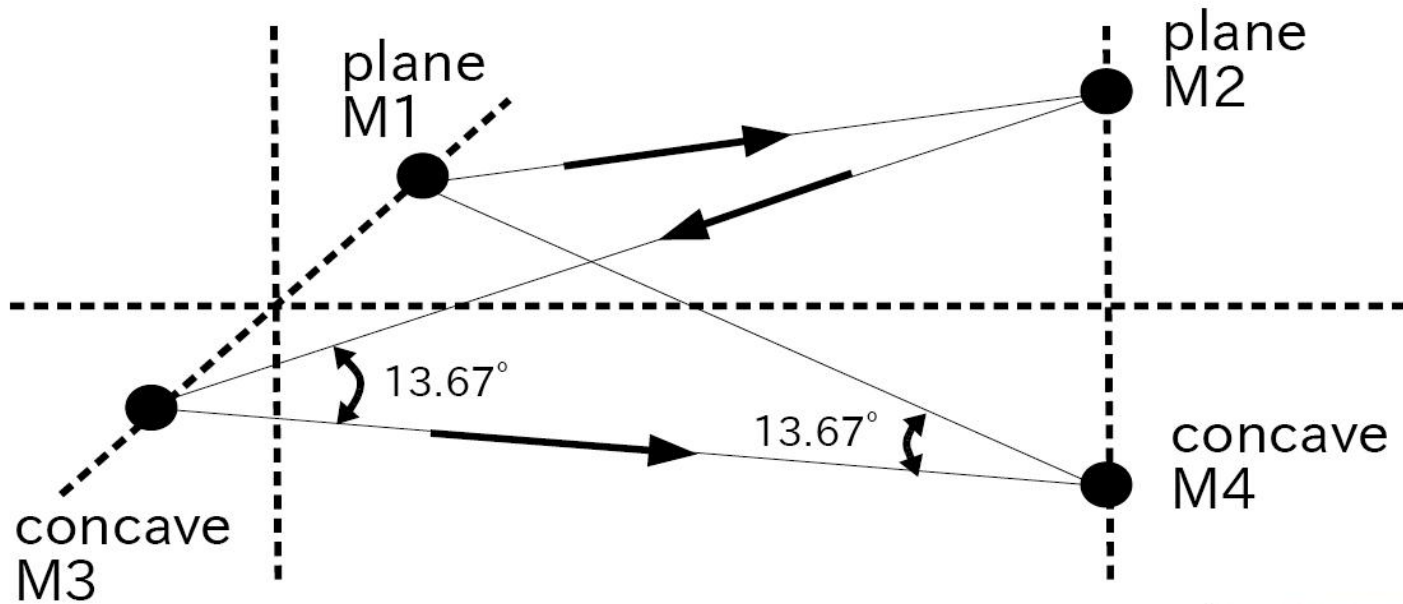
3 Dimensional 4 Mirror Cavity

- ▶ Resonates only for circular polarization
 - geometric phase due to twisted pass
 - cavity only resonates with circular polarization
 - usable for pol. switching



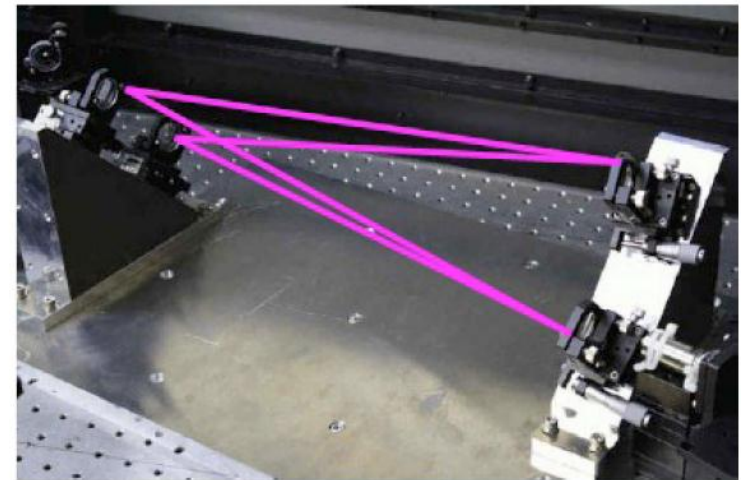
→
circumference of the cavity

Configuration of test bed

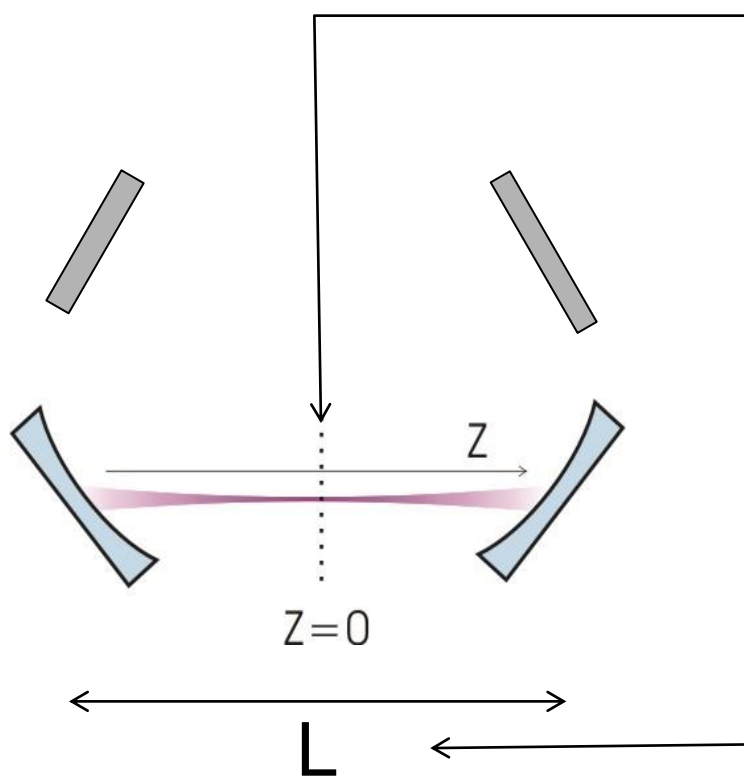
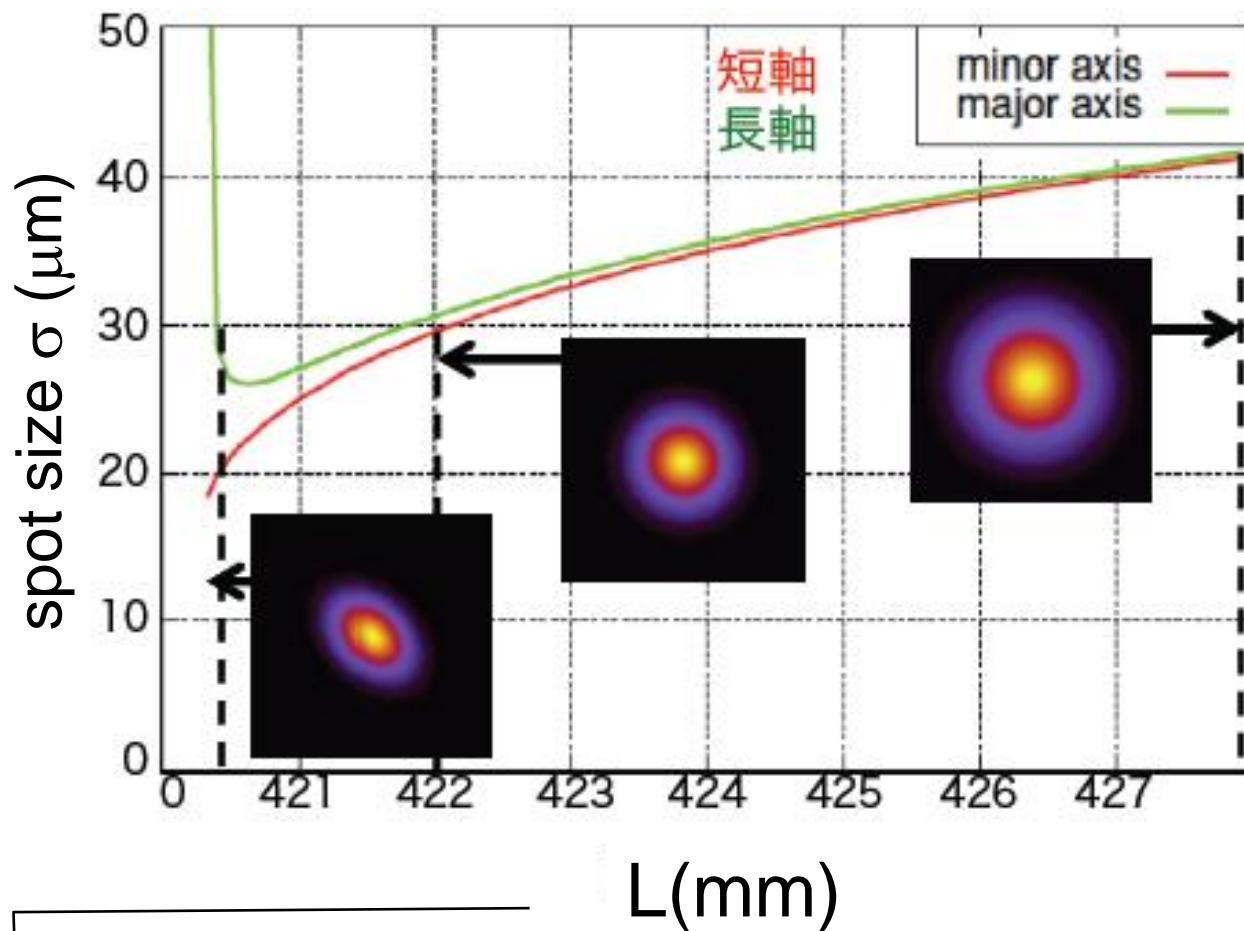
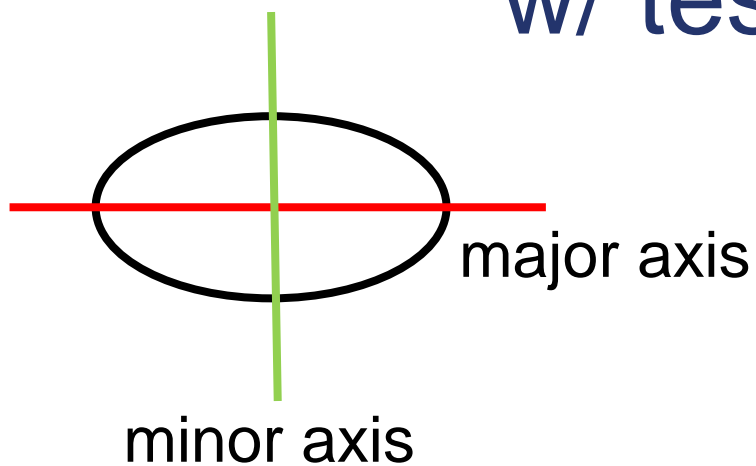


$L1 = M1 - M2 = 420\text{mm}$
 $L2 = M2 - M3 = 420\text{mm}$
 $L3 = M3 - M4 = 420\text{mm}$
 $L4 = M4 - M1 = 420\text{mm}$

$M2 - M4 = 100\text{mm}$
 $M1 - M3 = 100\text{mm}$

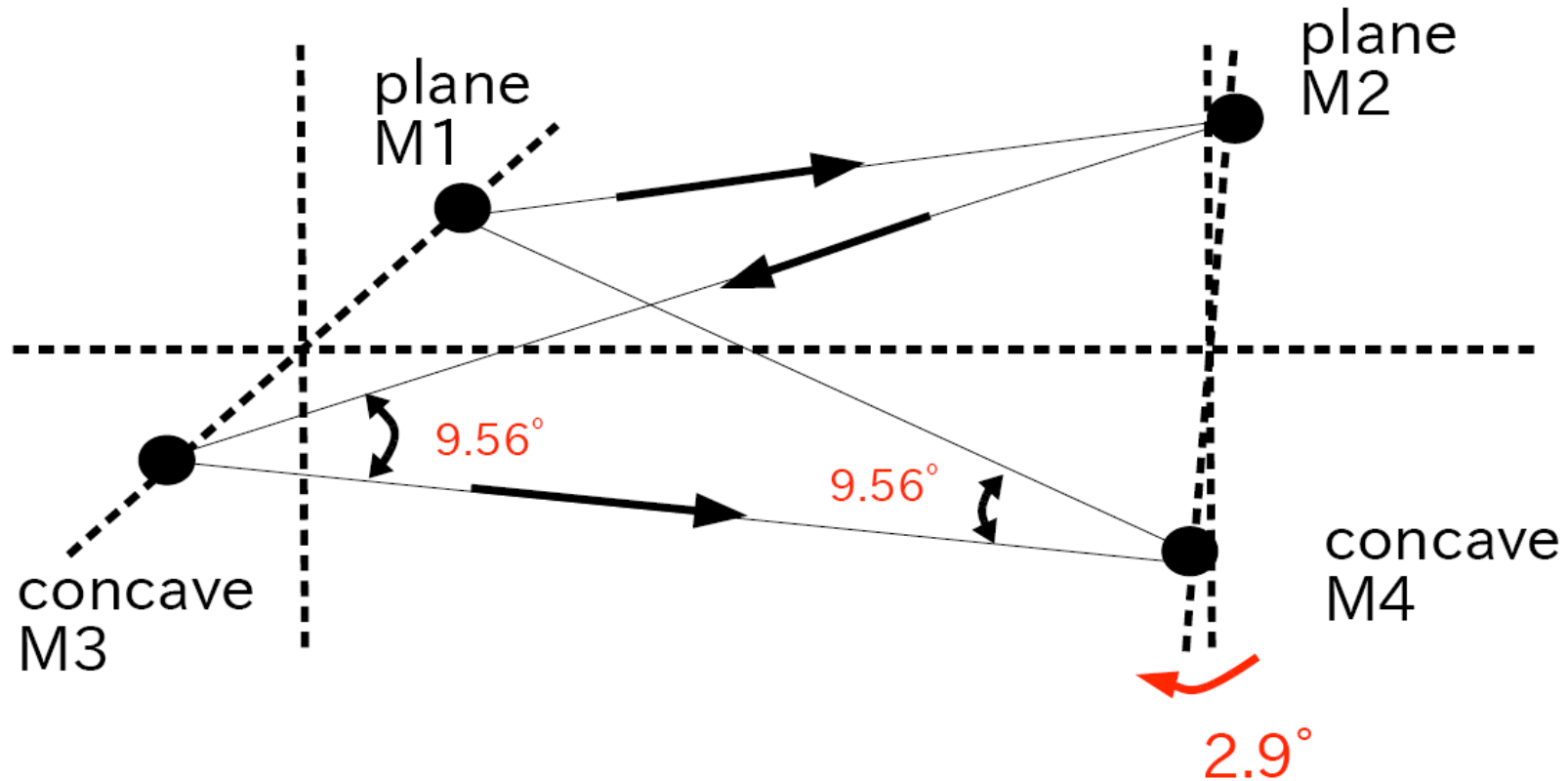


calculation of spot size w/ test bench geometry



spot size is not sufficiently small
with test bench geometry

new geometry



$L1 = M1 - M2 = 420\text{mm}$
 $L2 = M2 - M3 = 420\text{mm}$
 $L3 = M3 - M4 = 420\text{mm}$
 $L4 = M4 - M1 = 420\text{mm}$

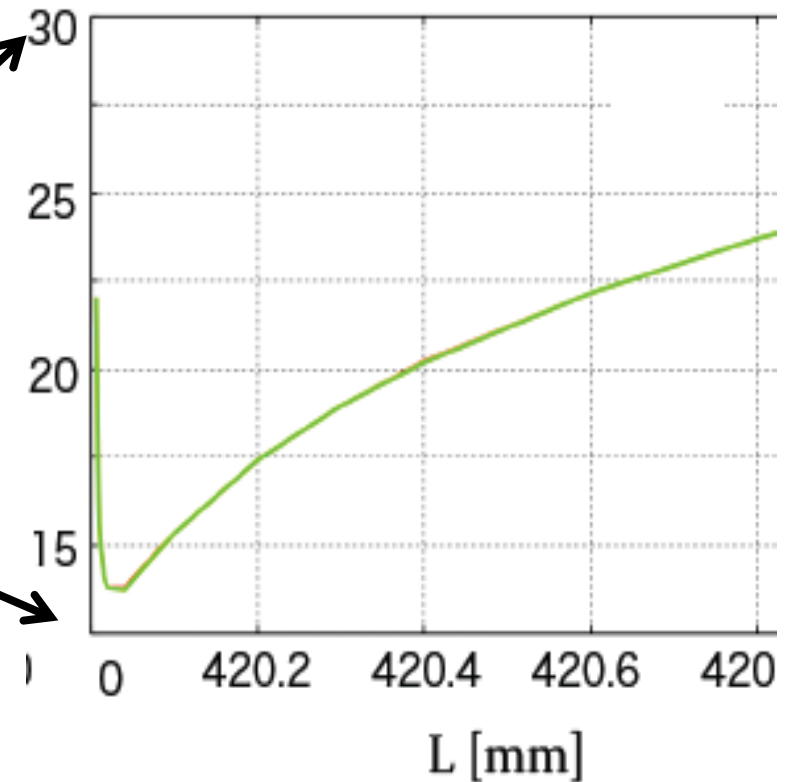
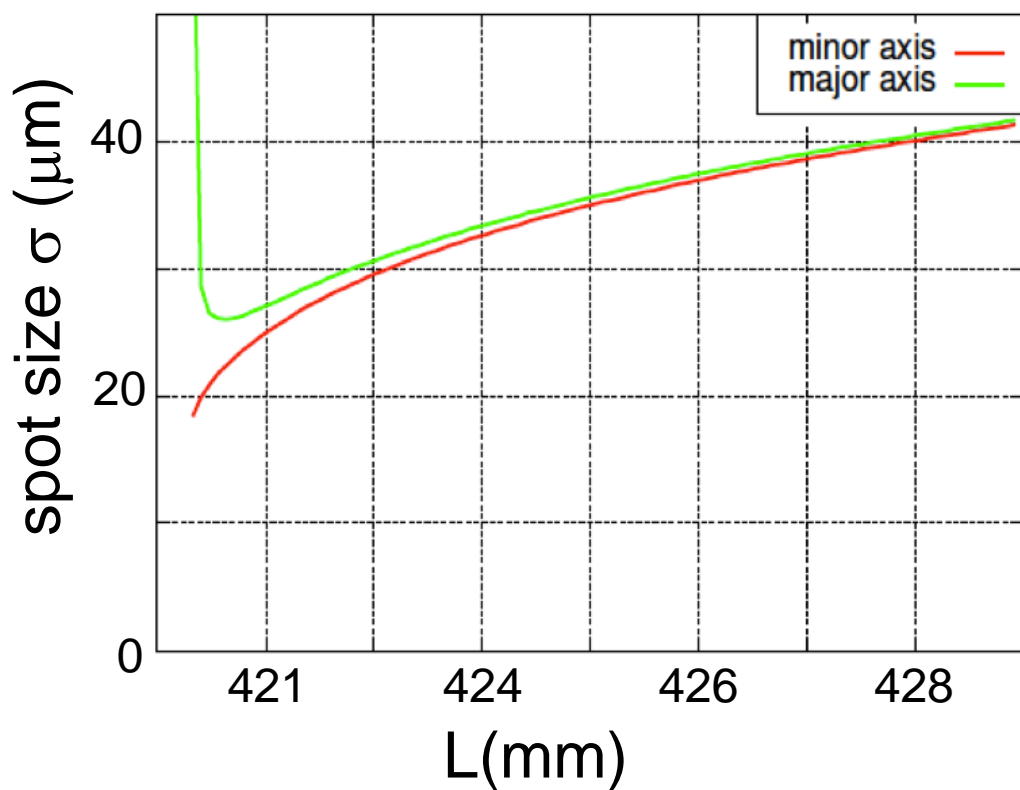
$M2 - M4 = 70\text{mm}$
 $M1 - M3 = 70\text{mm}$

expected spot size w/ new geometry

Before optimization

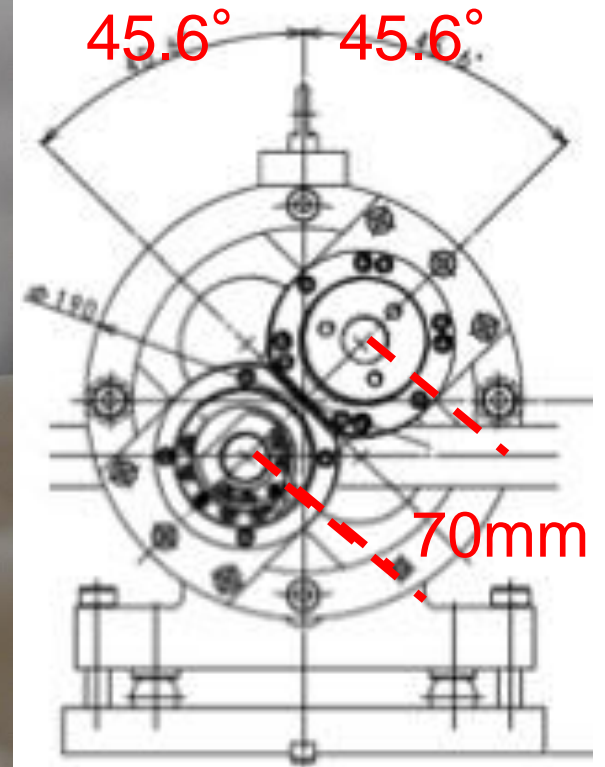
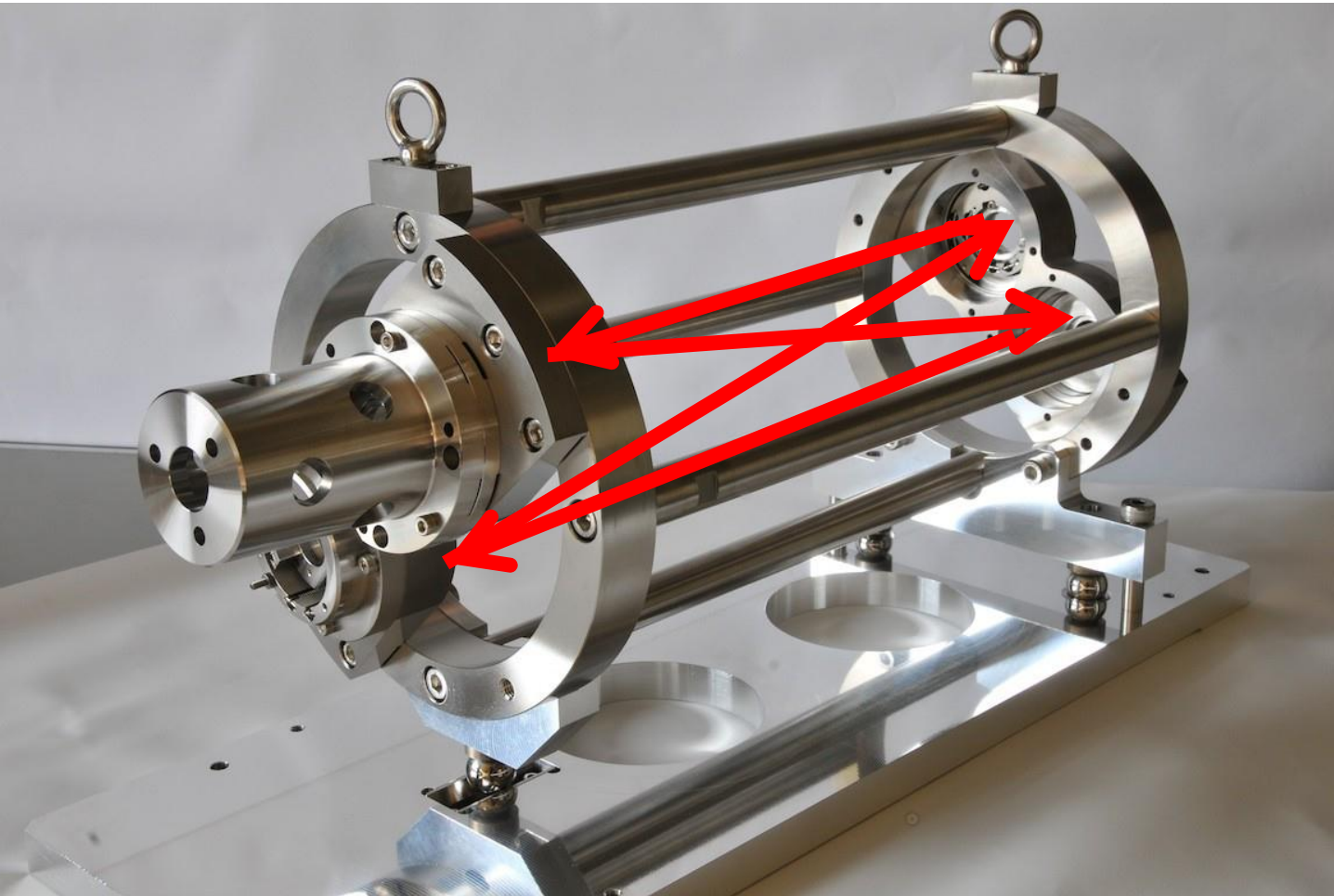


After optimization



laser spot size of 15 μm is expected with new geometry

New cavity to be installed into the ATF



Two 4 mirror cavities are at the ATF

KEK-Hiroshima
installed 2011

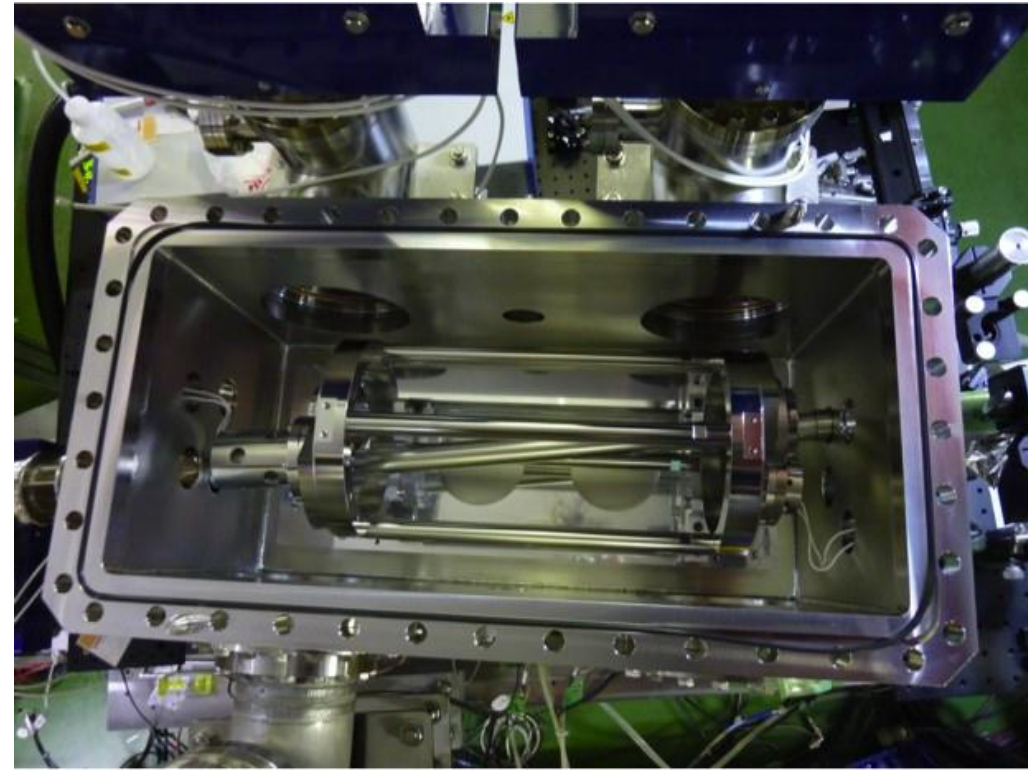
relatively simple control system
employs new feed back scheme

LAL-Orsay
installed summer 2010

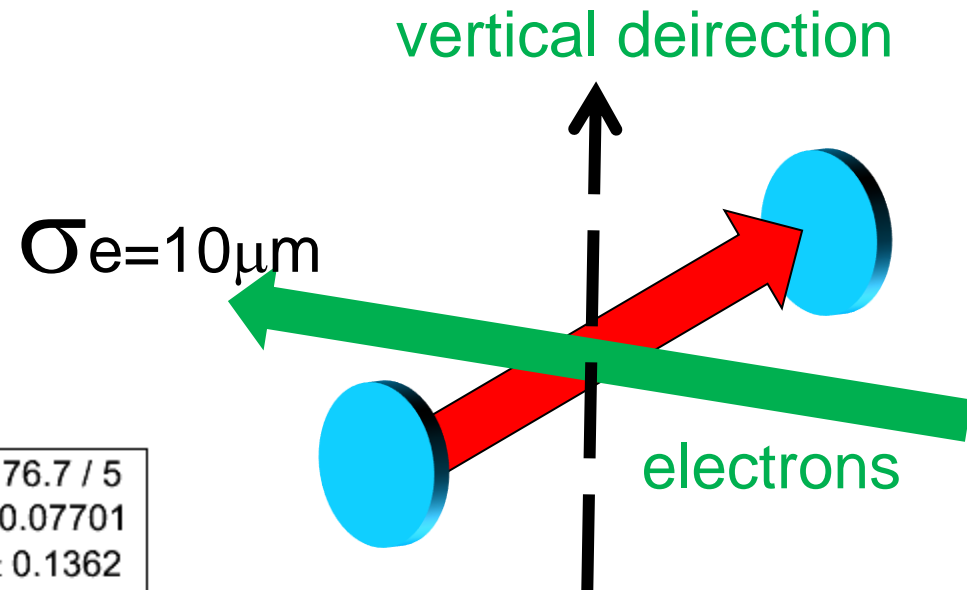
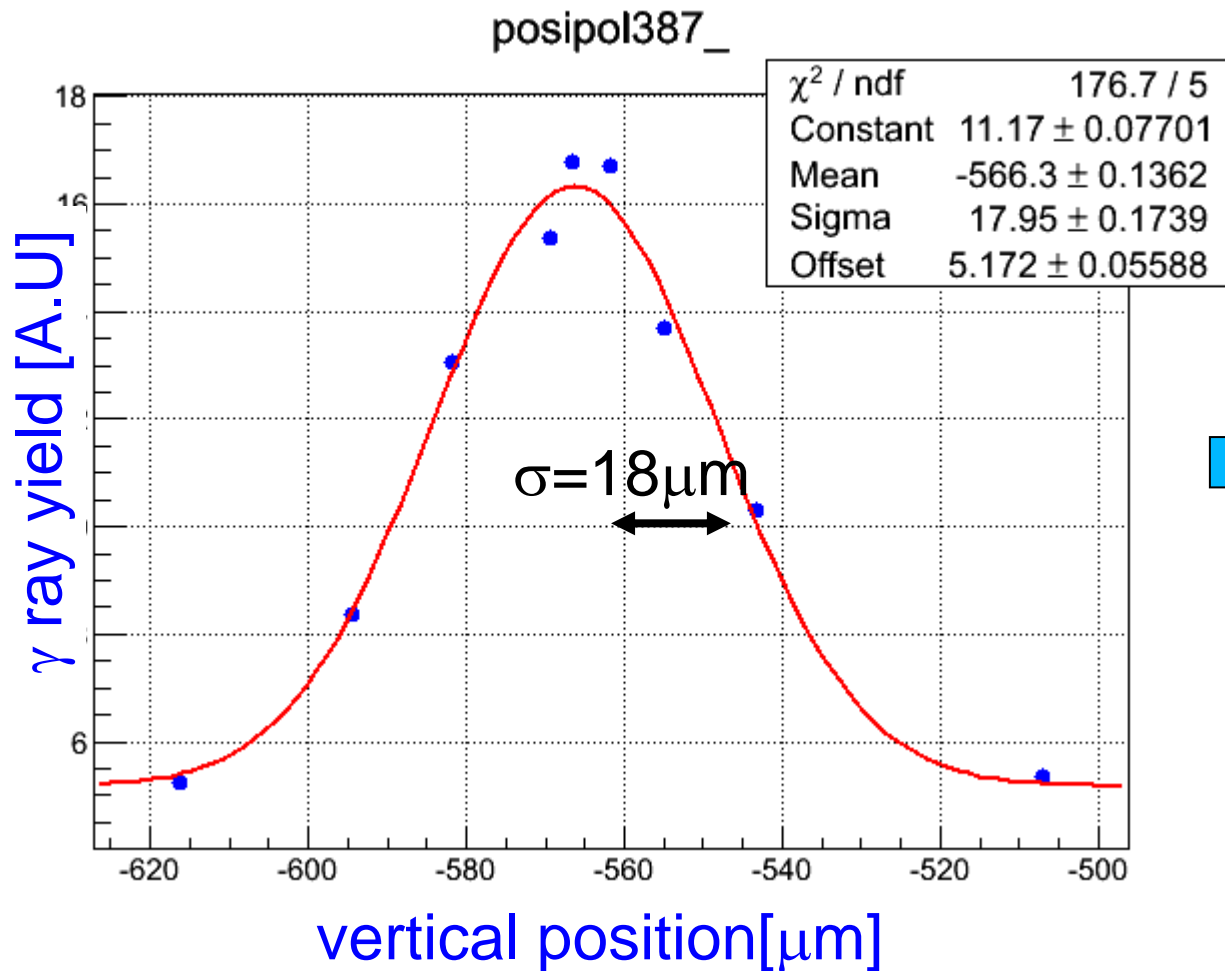
sophisticated control
digital PDH feedback



Installation of KEK Hiroshima cavity



Laser spot size 15 μm achieved



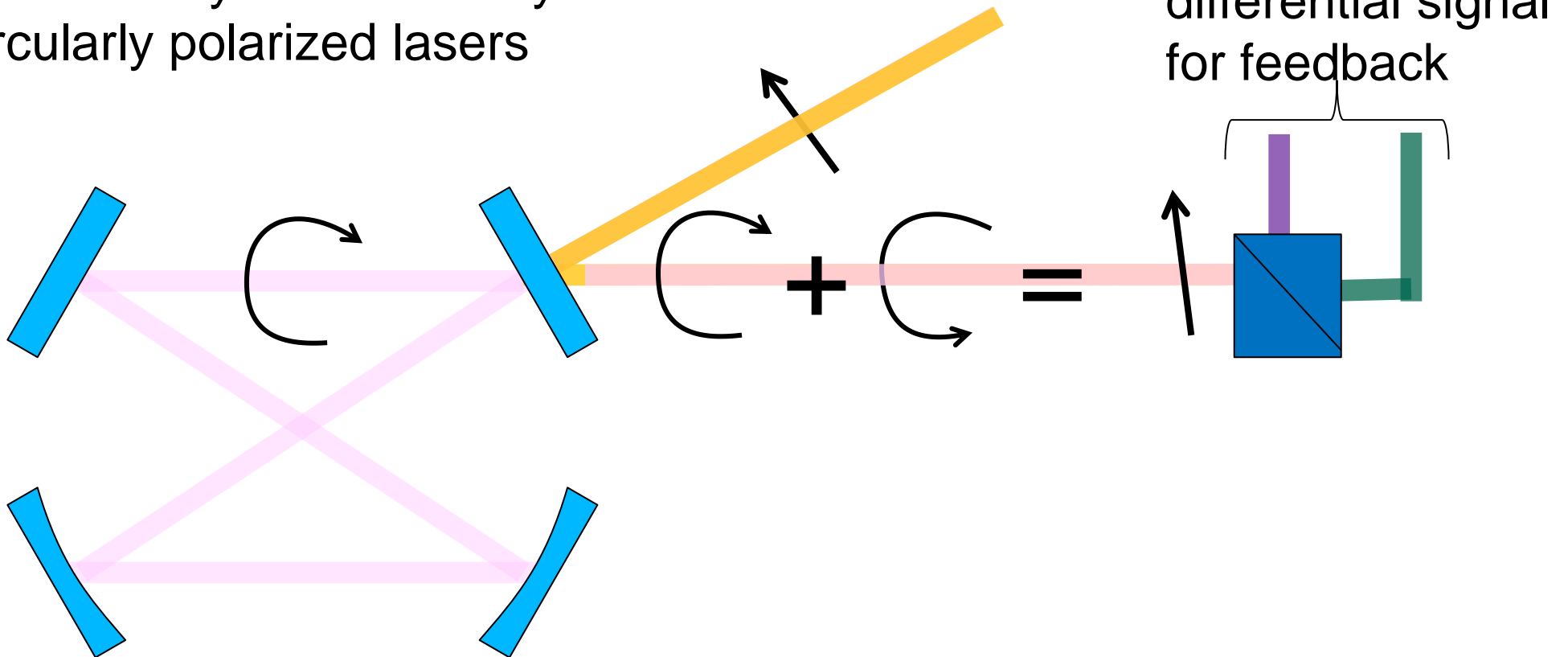
$\sigma_L = 15\mu\text{m}$

it was 30 μm w/ 2 M cavity

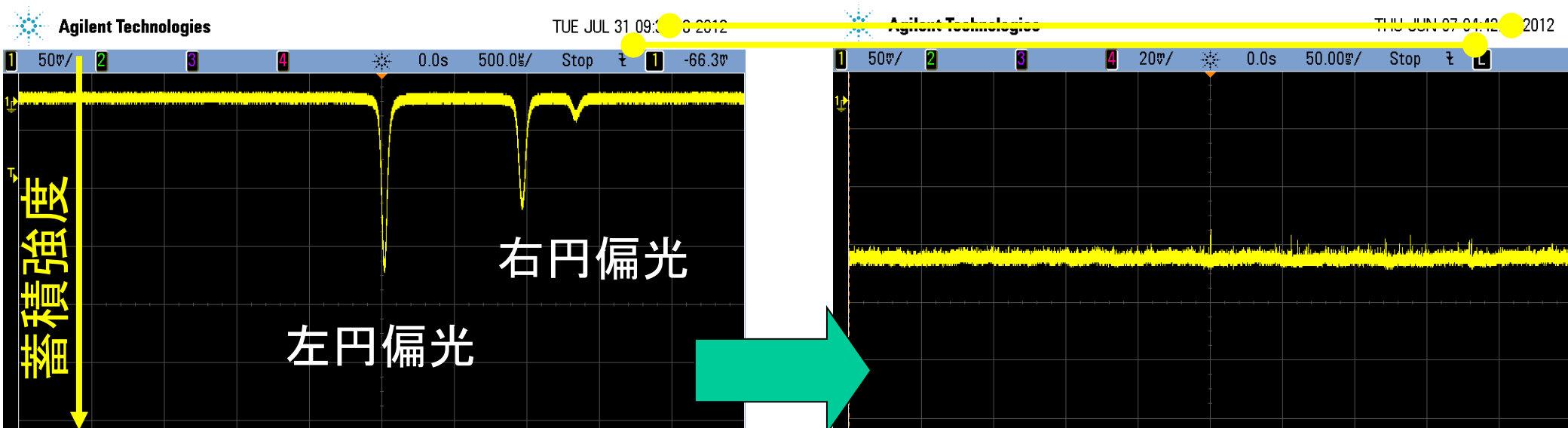
Cavity length feedback with 3D feature

cavity length must be $L = n\lambda/2$ with very high precision
(for enhancement of 1900 $dL \ll 87\text{pm}$ while $L = 1.64\text{m}$)

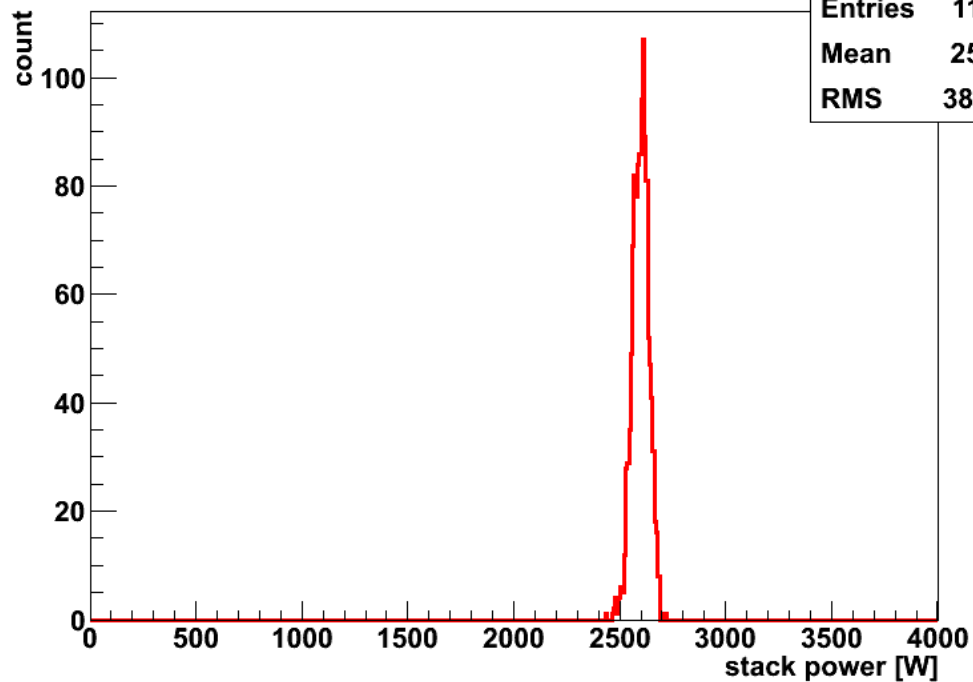
3D4M cavity resonate only with circularly polarized lasers



Stored Laser Power in the cavity



stack_power



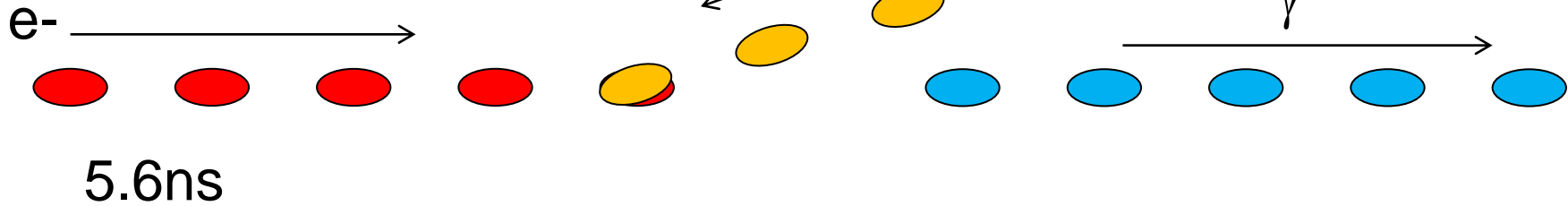
stack_power

Entries	1164
Mean	2598
RMS	38.15

Laser Power 2.6kW
Time Jitter = 8.0ps

g ray Generation / electron

5 bunches/train

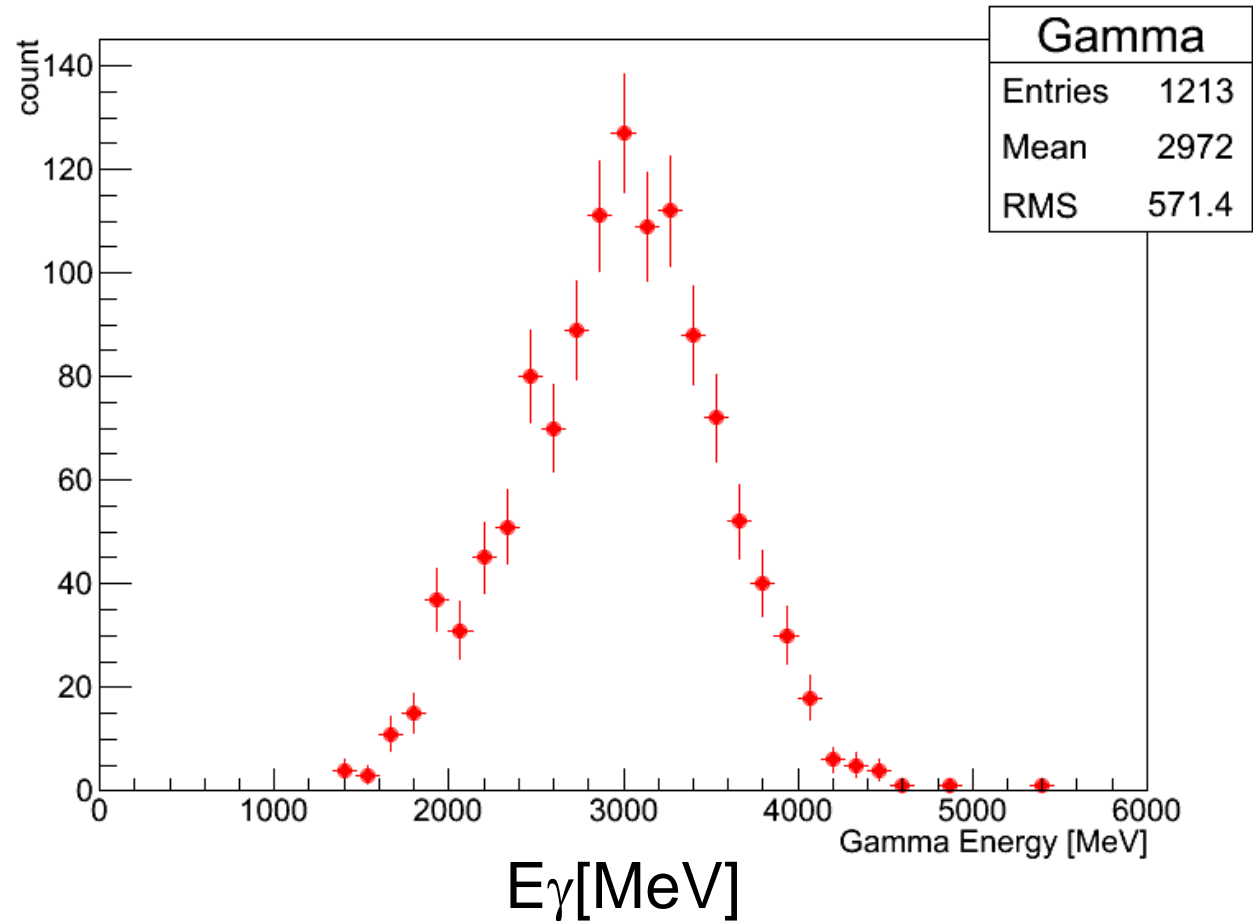


2970 ± 20 MeV

$\Rightarrow \sim 120 \gamma$ /train

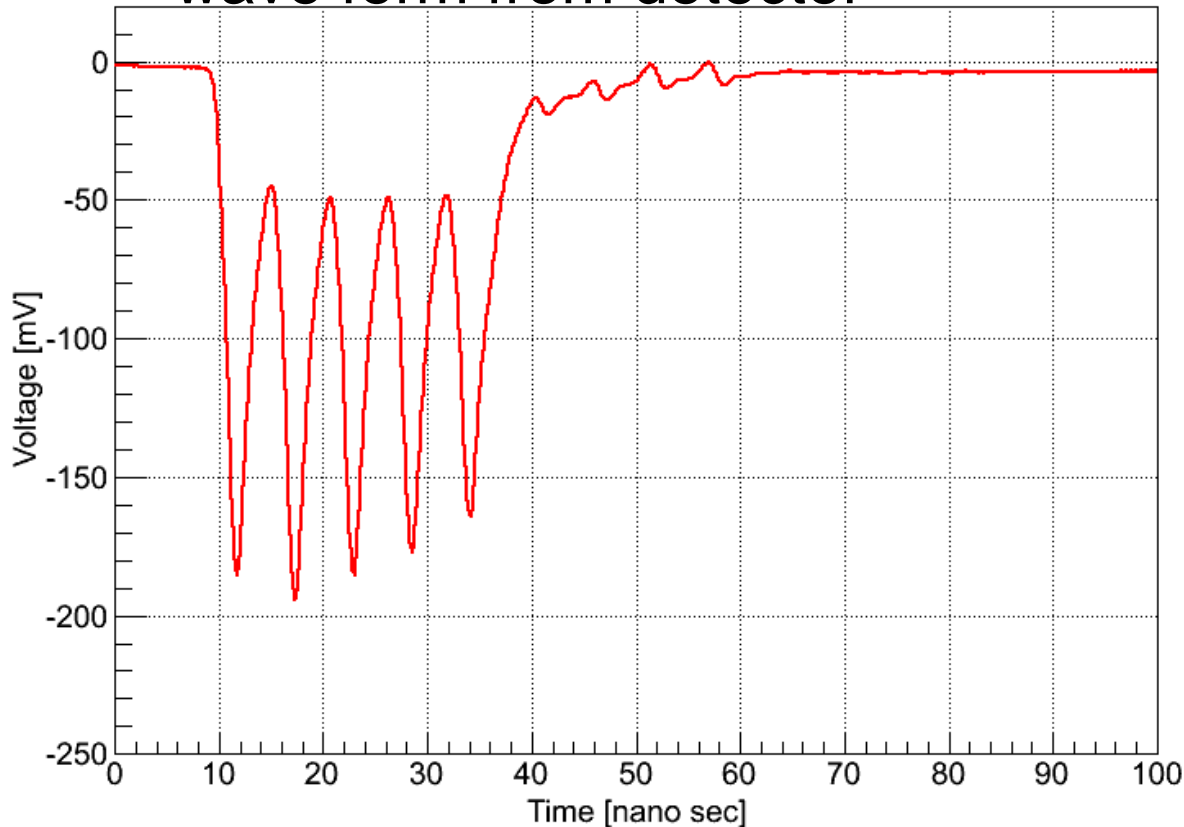
ATF 2.16MHz

$\sim 2.6 \times 10^8$ /sec

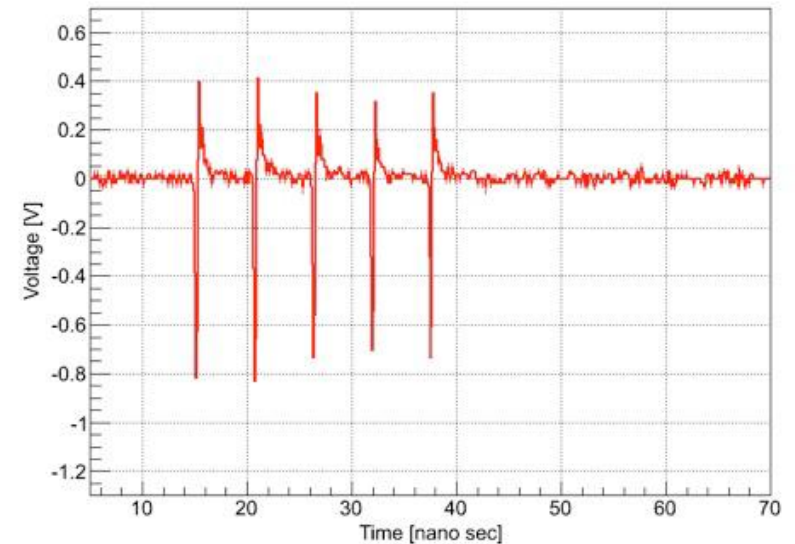


bunch/bunch measurement

wave form from detector



e- bunch monitor



- ◆ $\sim 117/\text{train} \Rightarrow$ consistent w/ calorimeter measurement
- ◆ no bunch dependence (yield is proportional to e- current)

Status and plan of KEK-Hiroshima cavity

- ▶ 2.6KW stored as of 25 May 2012
 - 30 γ s / bunch -> 150 γ s /train
 - correspond to 3.3×10^8 γ /s
- ▶ BaF2 detector was employed to observe bunch/bunch generation
 - Planed to be replaced w/ a Lead glass counter
 - used in TOPAZ barrel cal. at TRISTAN!
- ▶ Plan
 - more power enhancement
 - 16600 enhancement (finesse 48,000)
 - digital feedback

Summary

- ▶ Optical Cavity at the ATF is in progress for Polarized positron source for the ILC
 - Good collaboration between France - Japan team
 - information / technology exchange
- ▶ R&D of 4 mirror ring cavities are in progress
 - Sophisticated mechanism aiming very high laser power enhancement ... French team
 - Relatively simple but new cavity control practical experience w/ the ATF ... Japanese team
- ▶ More to come
 - more laser power, more γ rays
 - maturity toward the system