

Status of R&D of Optical Cavities at KEK-ATF

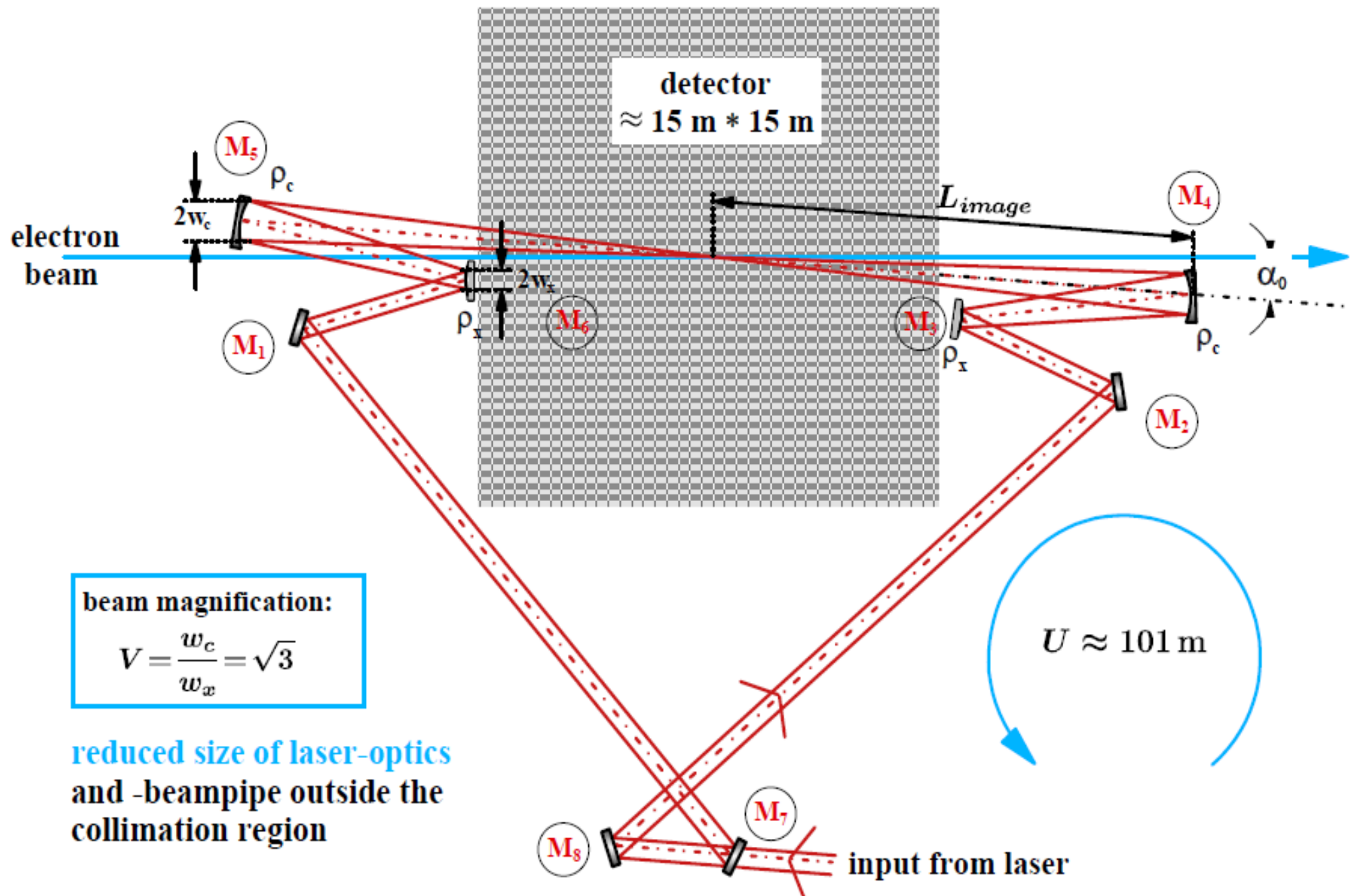
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for

KEK, Hiroshima University
LAL (Orsay) in Collaboration with CELIA (Laser lab.,
Bordeaux) and LMA (coatings Lab., Lyon)

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

28 May 2013
ECFA2013 DESY

Proposed telescopic, passive, resonant external cavity

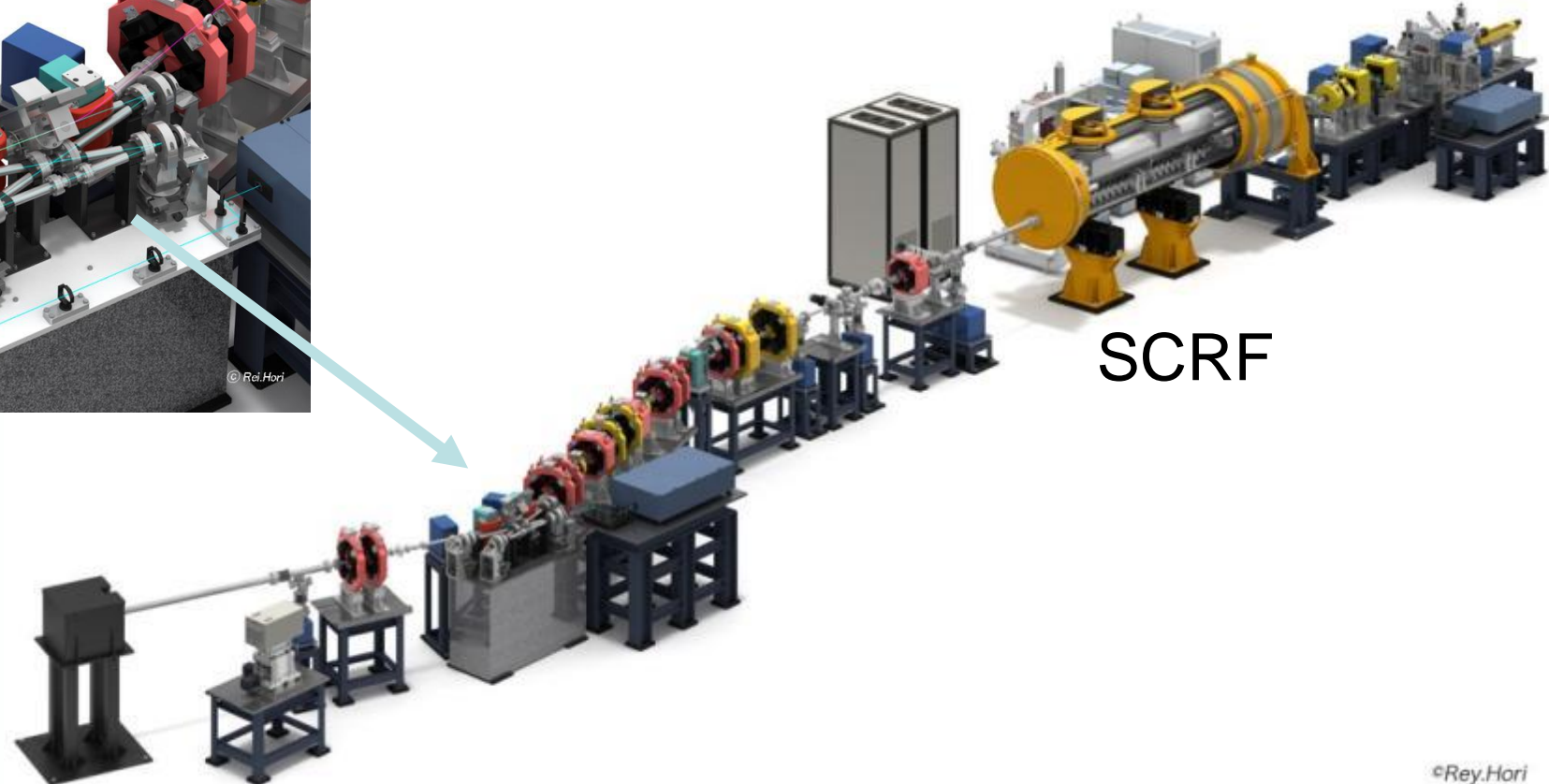
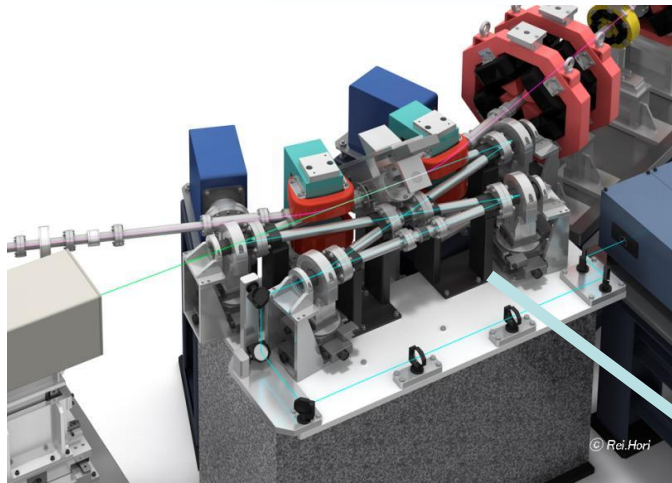


Optical cavity projects at KEK

- 3D4M cavity for gamma ray at ATF
- 2D2M cavity X-ray. LUCX
- 2D4M cavity for X-ray with two cylindrical lenses
- Compact 2D4M cavity for fast laser wire scanner

Quantum Beam Technology Program (QBTP)

Development for Next Generation Compact High Brightness X-ray Source using Super Conducting RF Acceleration Technique

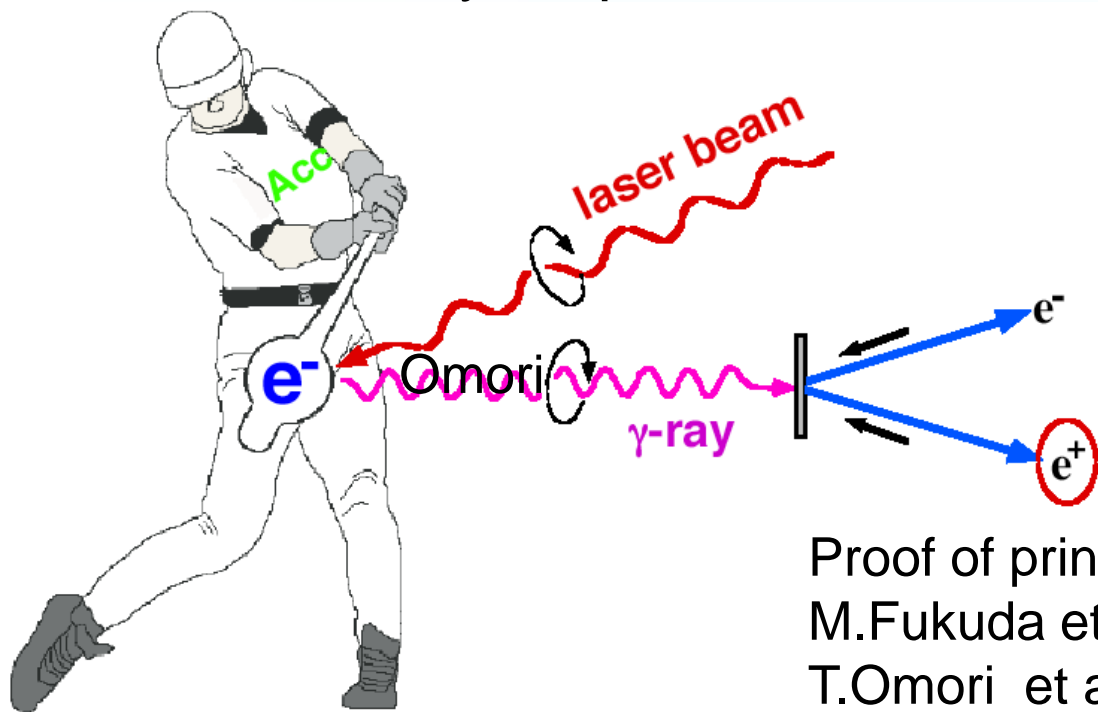


First Compton X ray in
March 2013

Compton at KEK ATF

- Polarized e^+ by laser Compton Scheme

$E_e \sim 1\text{GeV}$ for 10MeV gammas
controllability of polarization



Proof of principle

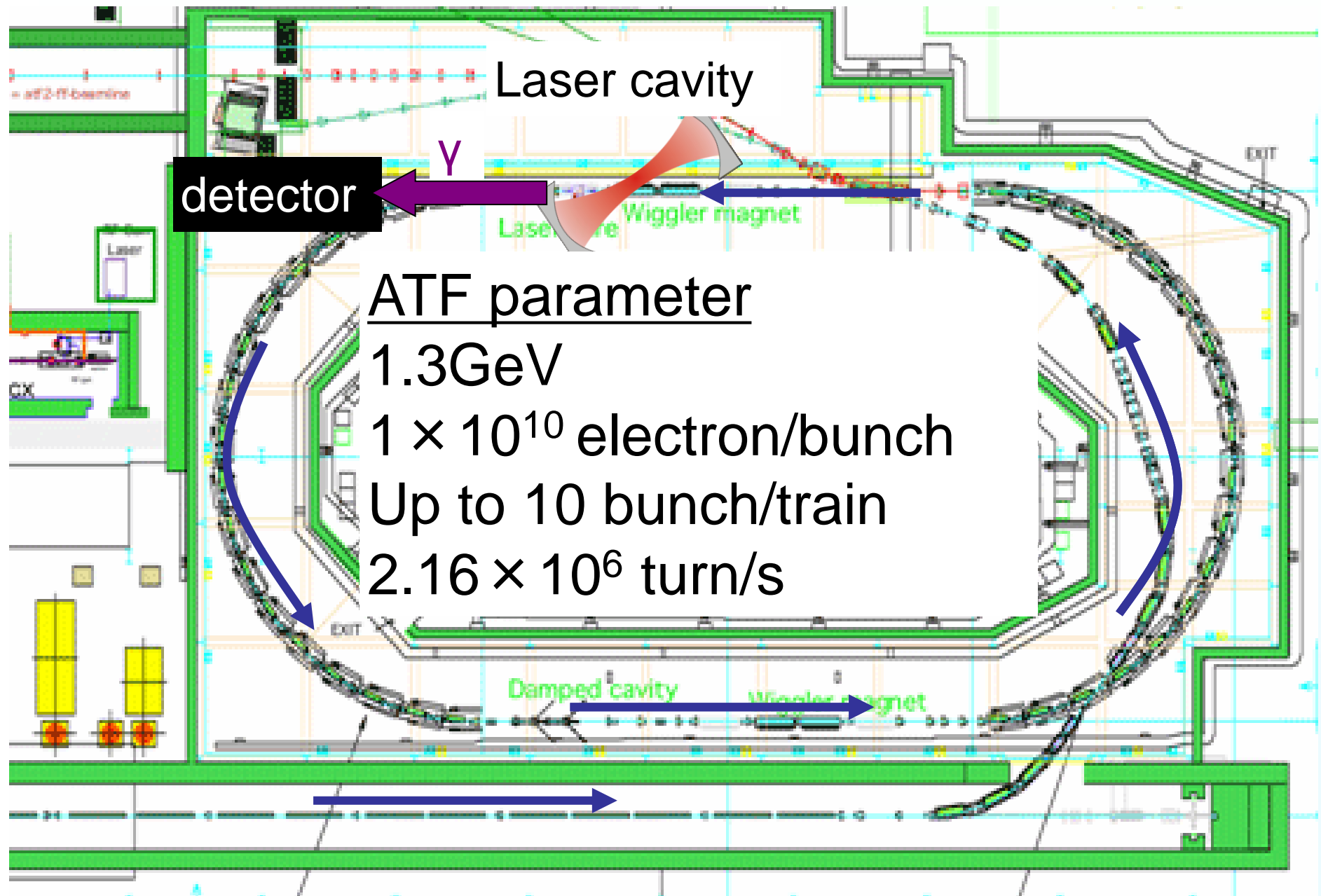
M.Fukuda et al., Phys. Rev. Letts. 91, 16480(2003)

T.Omori et al., Phys. Rev. Letts. 96, 114801(2006)

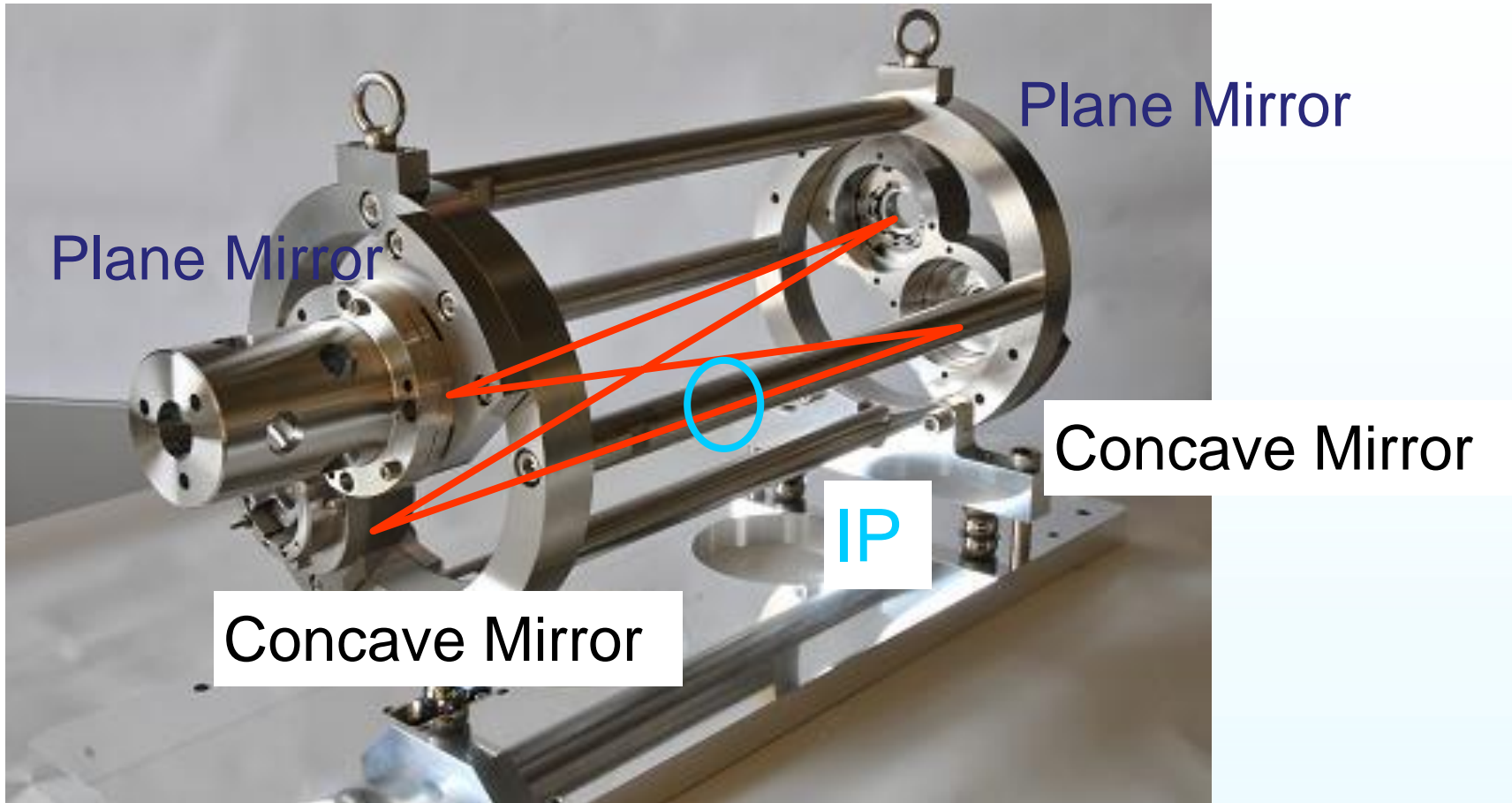
Toward the positron sources

—> increase intensity of © rays

Setup at the KEK-ATF



The Optical Cavity



Main Parameters

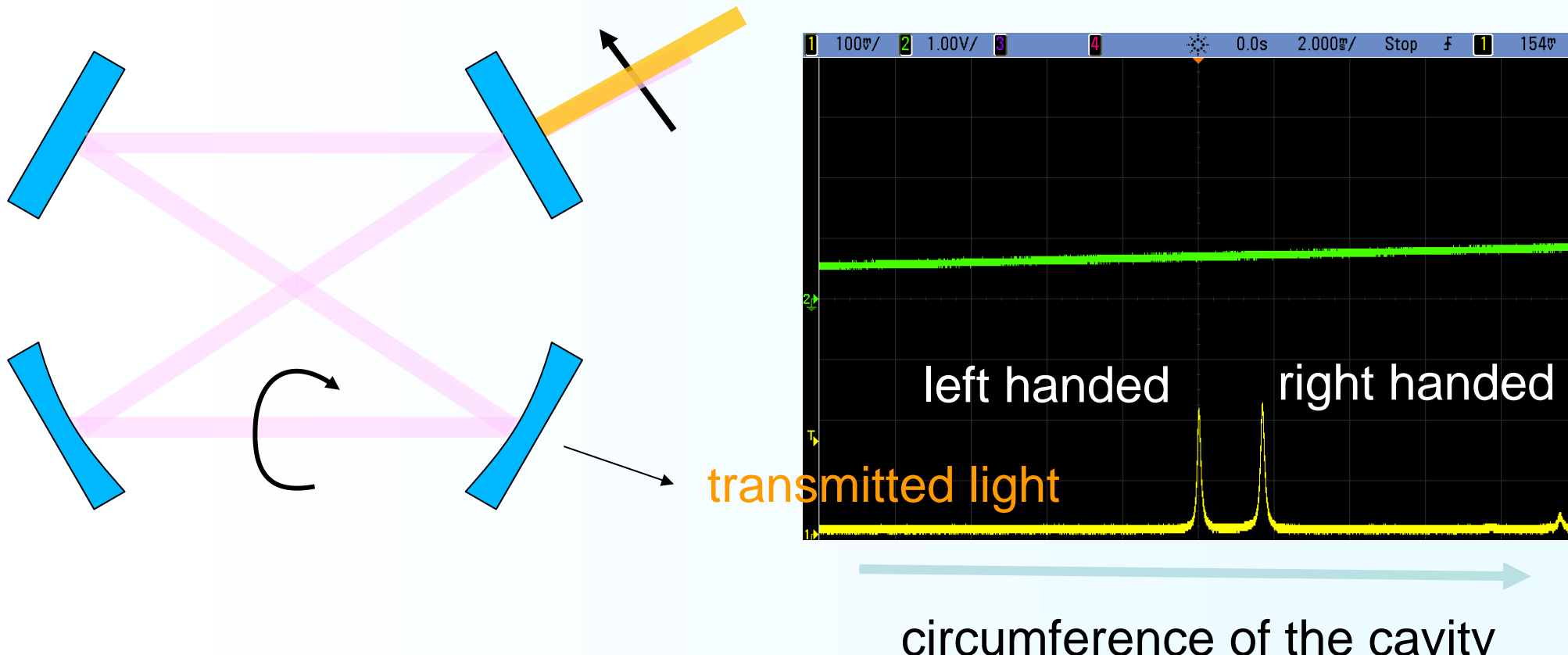
Circumference: 1.68m

Finesse: 4040 (Measured)

Power Enhancement: 1230

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



4 mirror cavities are at the ATF

KEK-Hiroshima
installed 2011

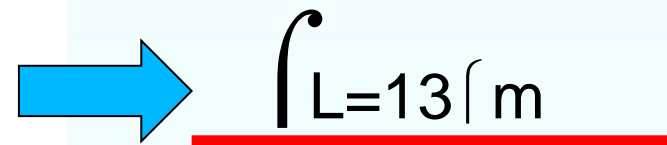
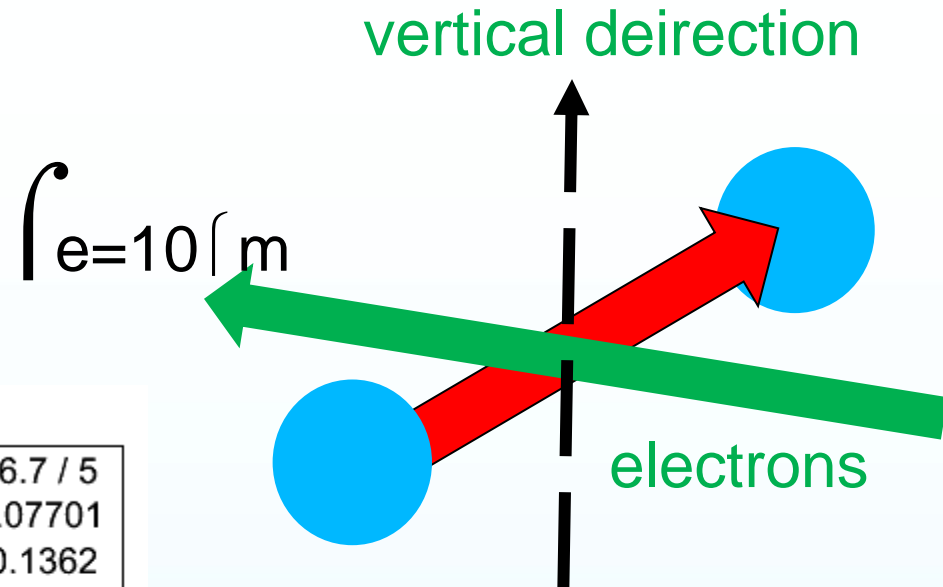
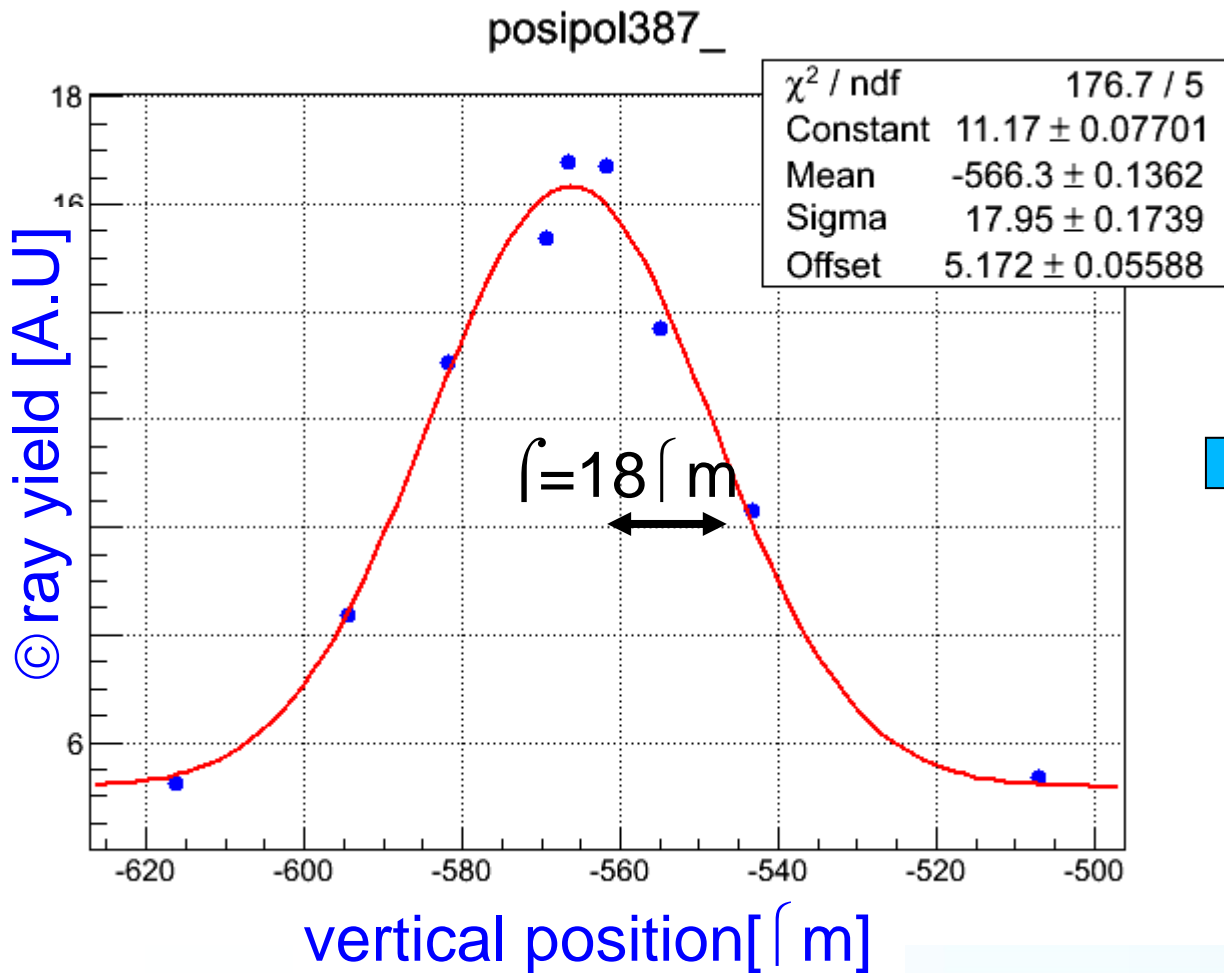
relatively simple control system
employs new feed back scheme

LAL-Orsay
installed summer 2010

sophisticated control
digital PDH feedback



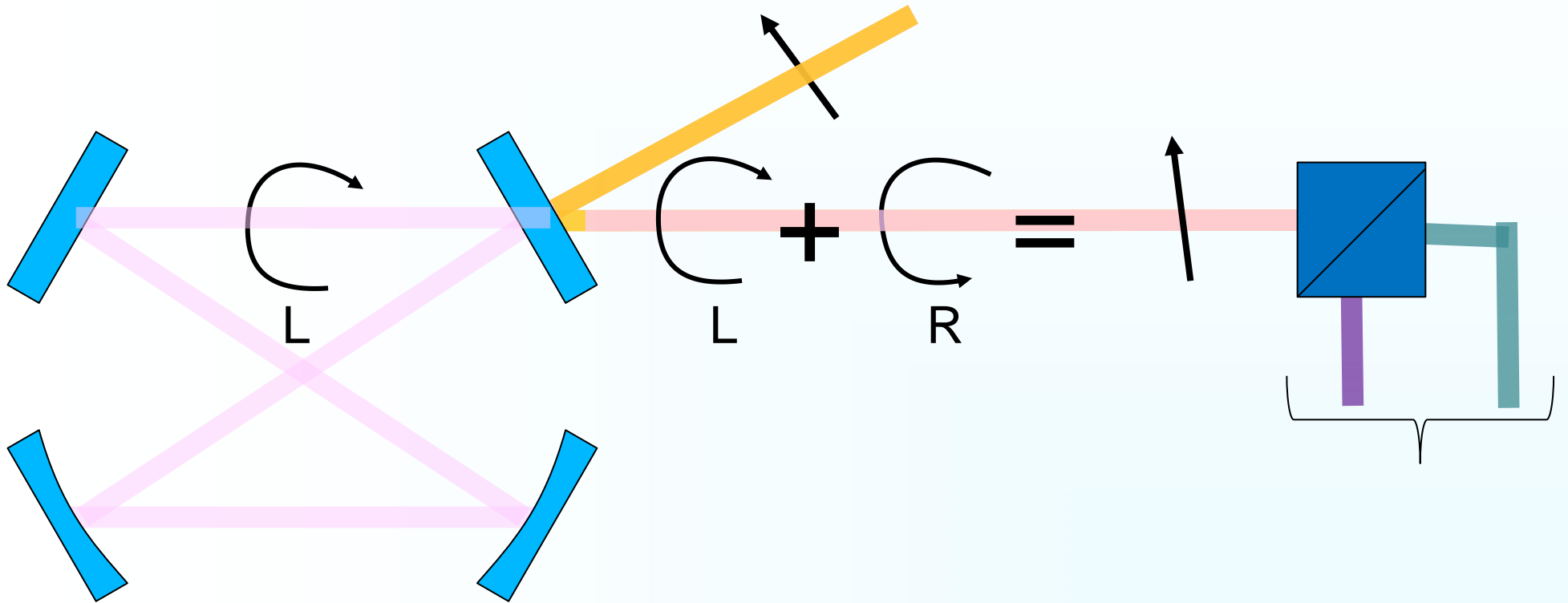
Laser spot size 15 μ m achieved



it was 30 μm w/ 2 M cavity

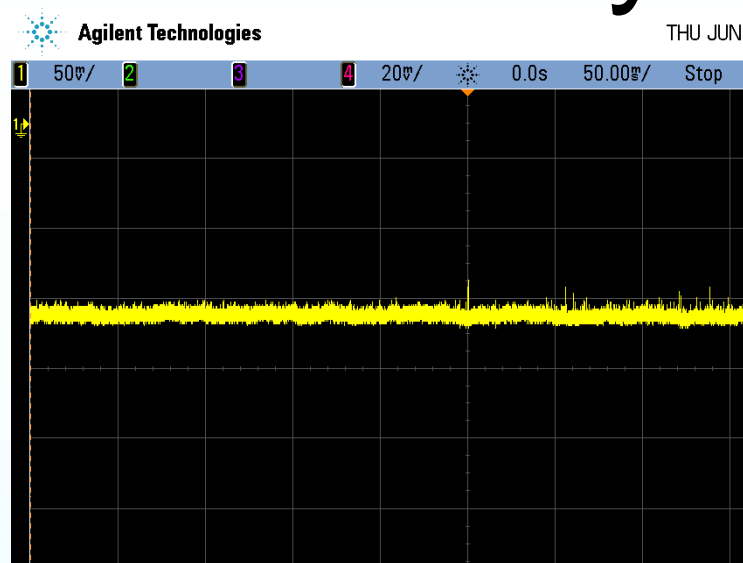
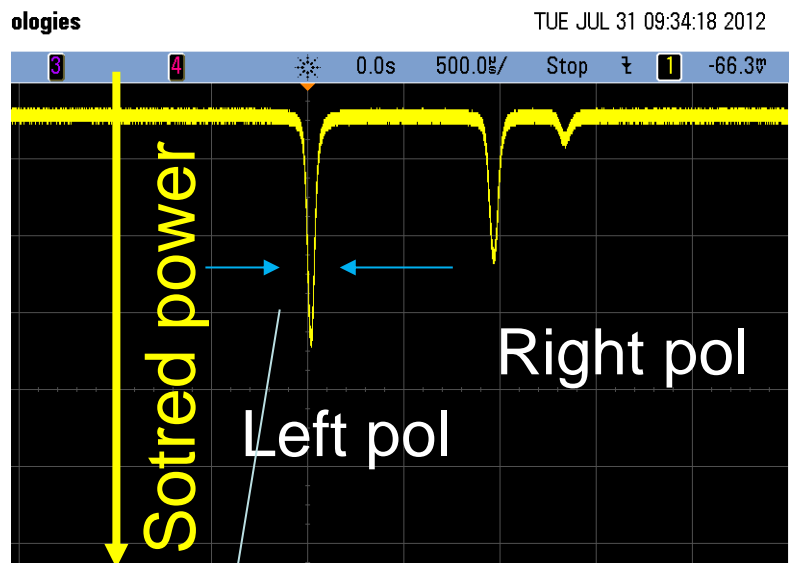
Cavity feedback with 3D feature

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

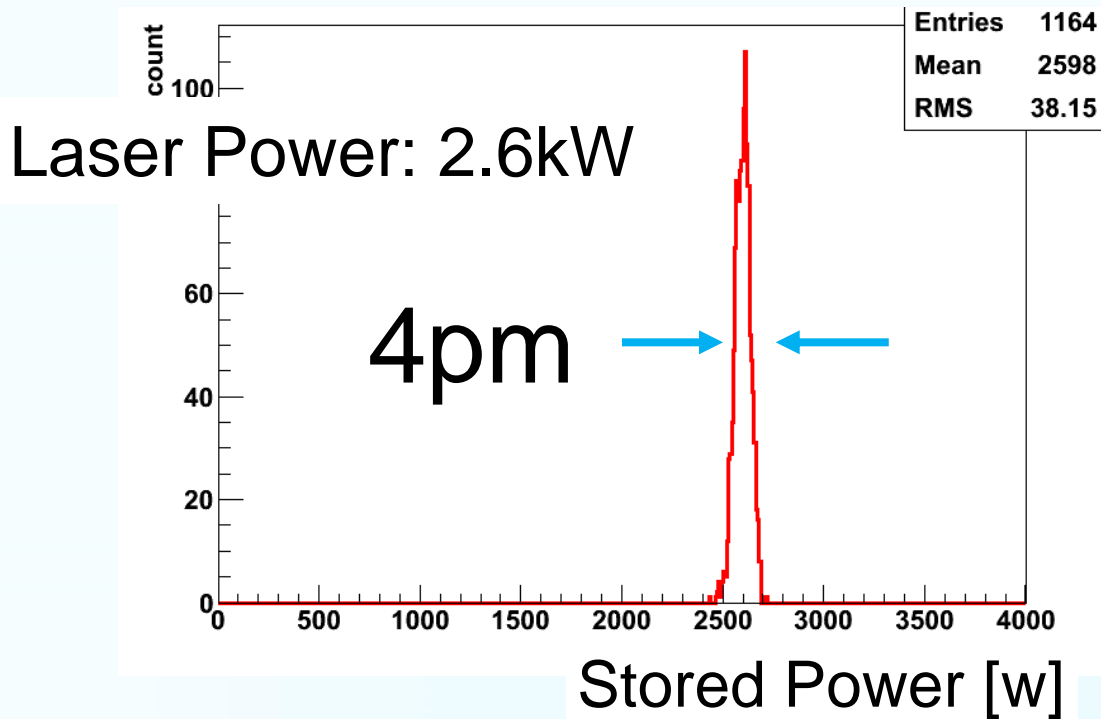


3D4M cavity resonate only with circularly polarized lasers

Stored Laser Power in the cavity



FWHM: 110pm



© ray Generation

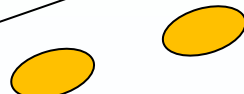
5 bunches/train

e⁻

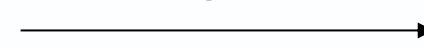


5.6 ns

laser



©

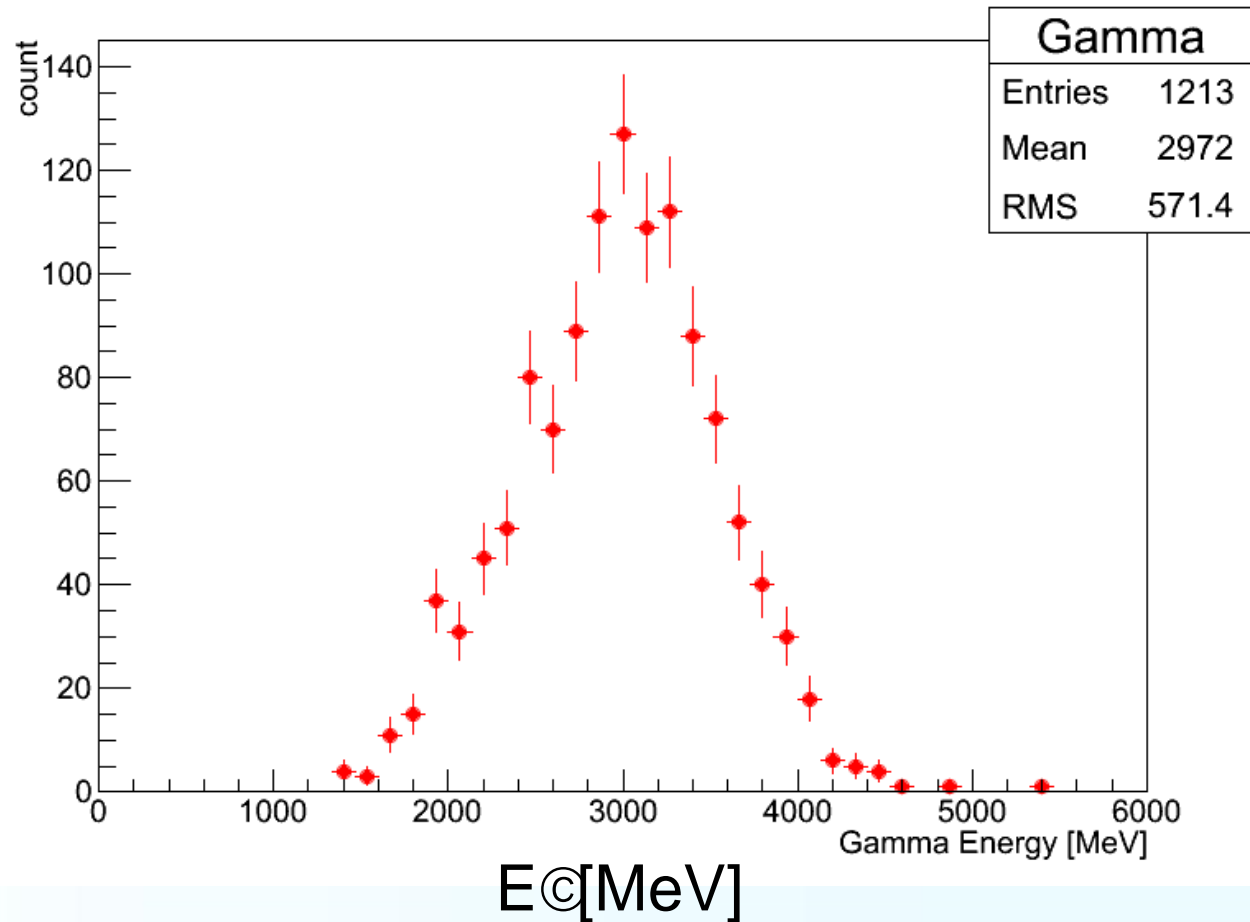


2970 ± 20 MeV

$\Rightarrow \sim 120$ ©s/train

ATF 2.16 MHz

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



Quantitative Understanding of the Cavity

- **Finesse**

- Airy function
- Life time of the laser light in the cavity

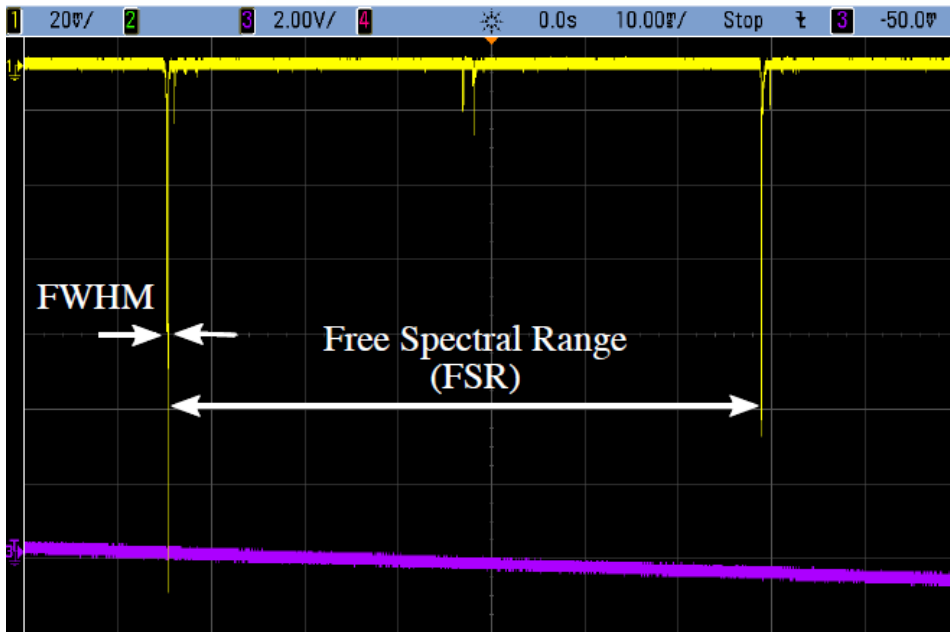
- **Stored Power in the cavity**

- From injection power
- From transmitted power

- **Profile at the interaction point**

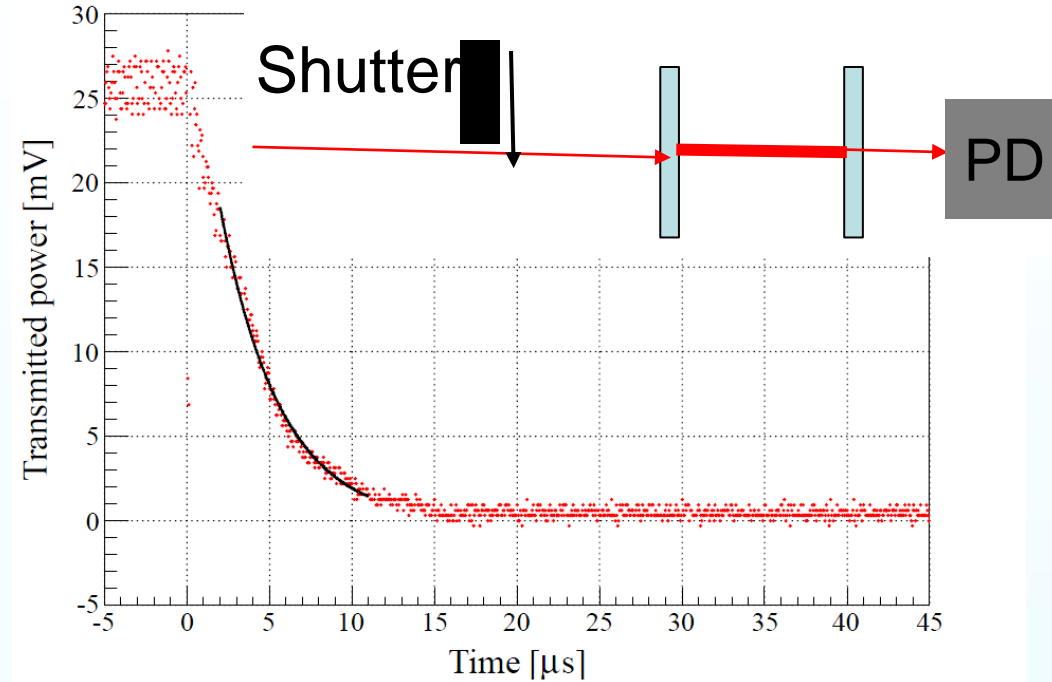
- Using Compton gamma (laser-wire)
- Estimate from a measured laser light profile

Finesse



Airy Function

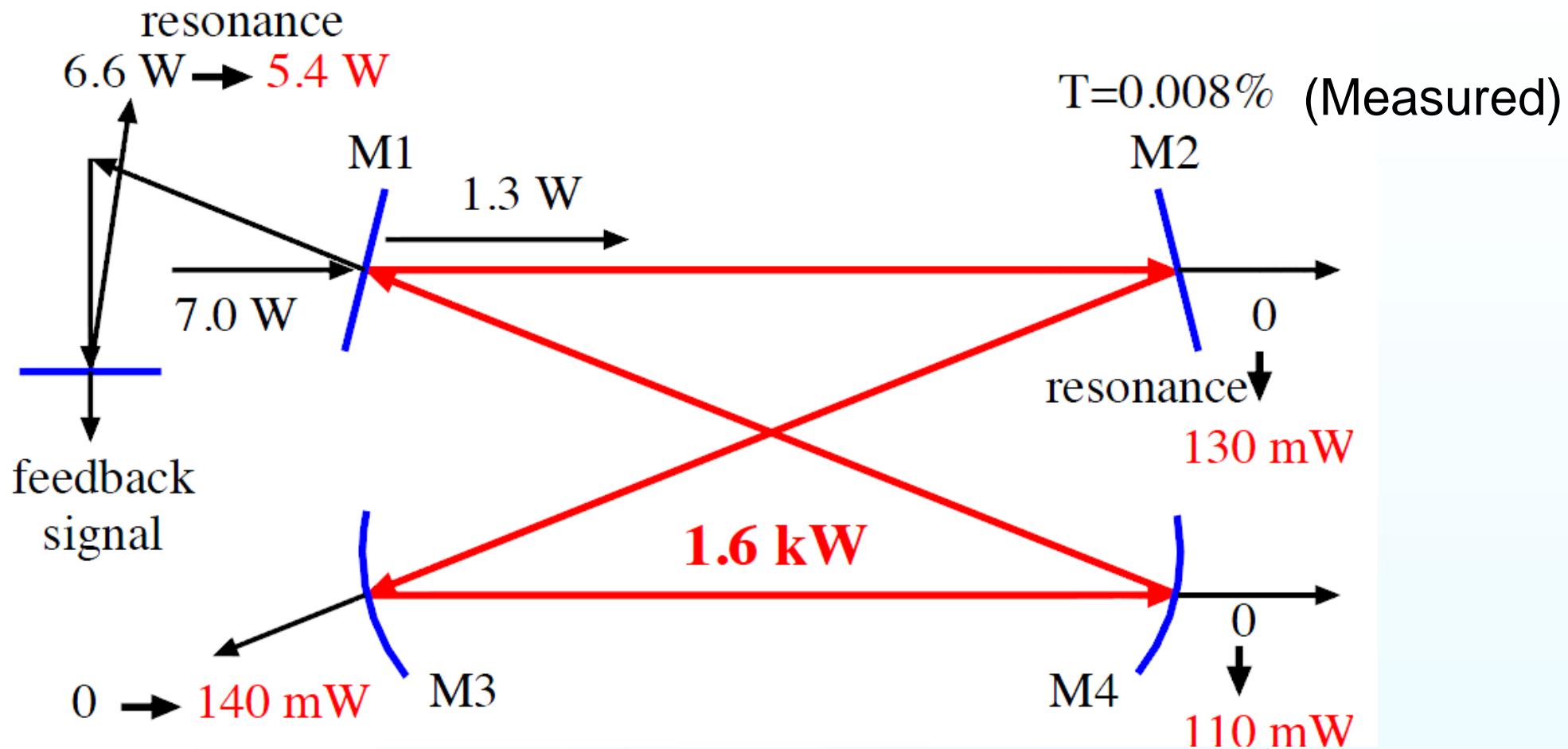
$$\text{Finesse: } \text{FWHM} / \text{FSR} \\ = 4040 \pm 420$$



Life time of the laser light

$$2\pi c \tau / L \\ = 4040 \pm 110$$

Stored Power

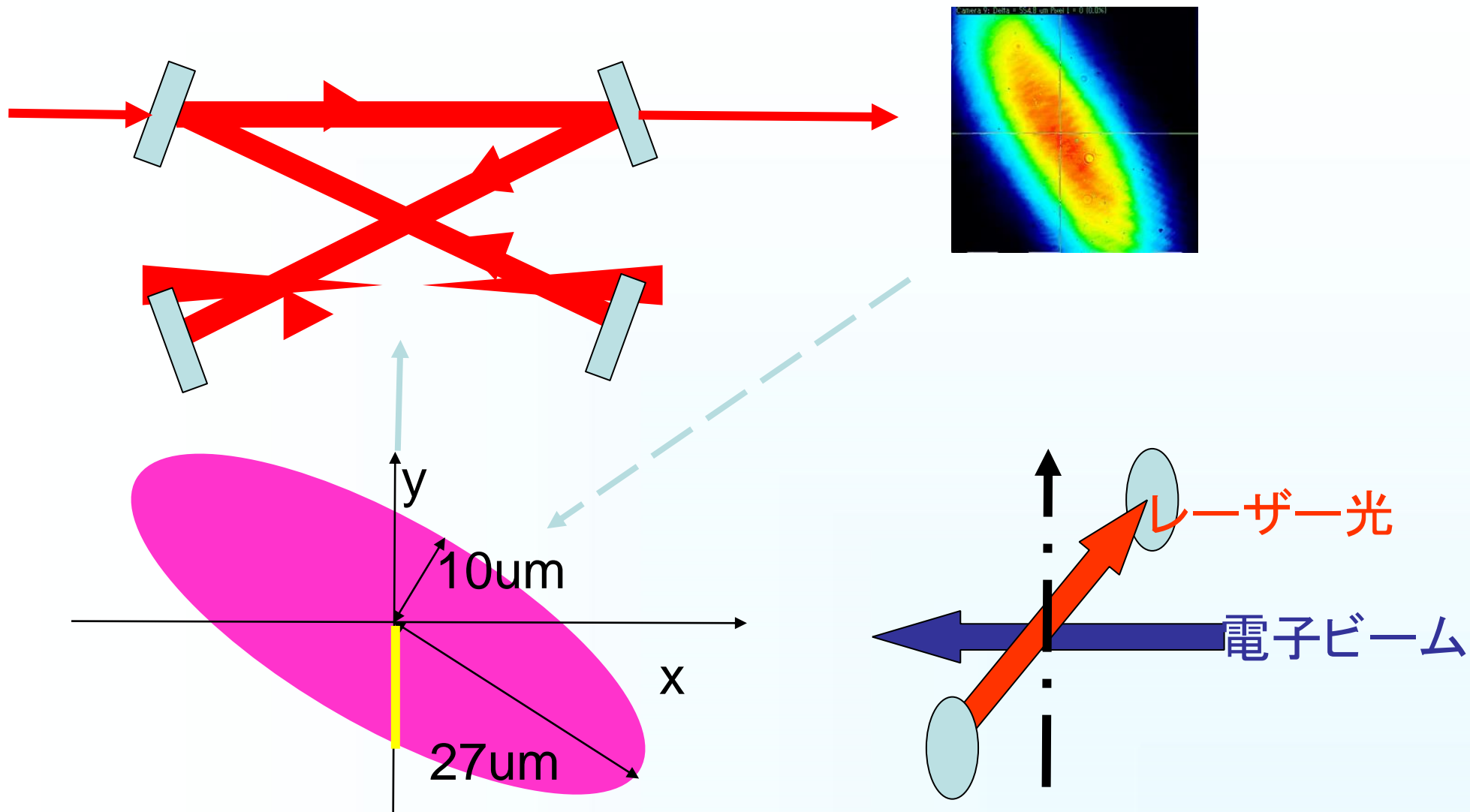


Two Estimates are consistent

$$\text{Injection}(1.3\text{W}) \quad \times \quad \text{Enhancement}(1230) = 1.6\text{kW}$$

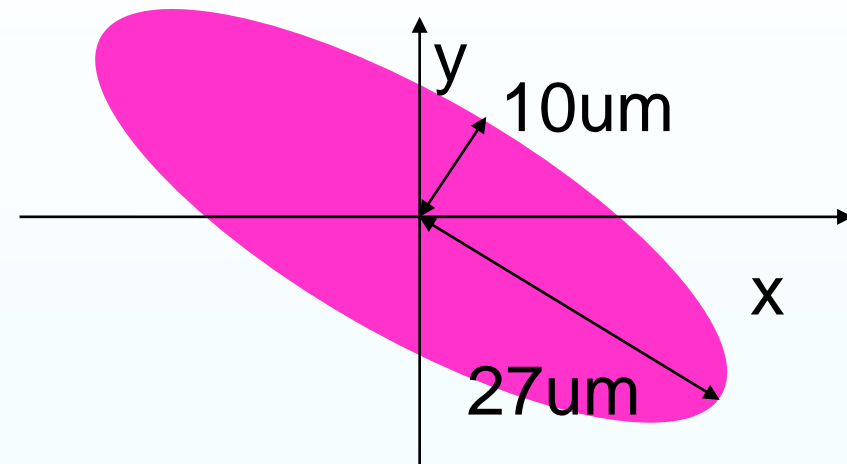
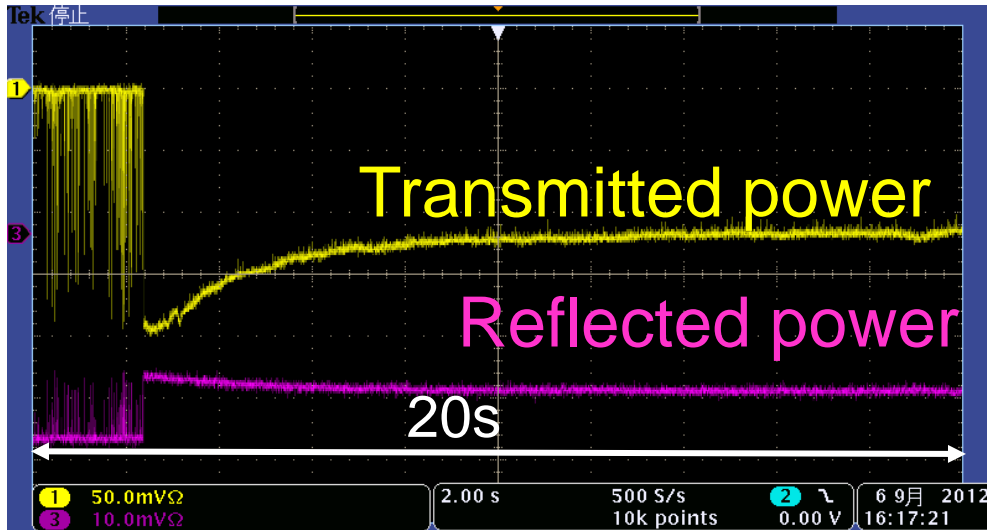
$$\text{Transmitted}(130\text{mW}) / \text{Transmittance}(0.008\%) = 1.6\text{kW}$$

Profile of the laser light at the IP



Calculated 16 μm
Measured 13 μm

Issues



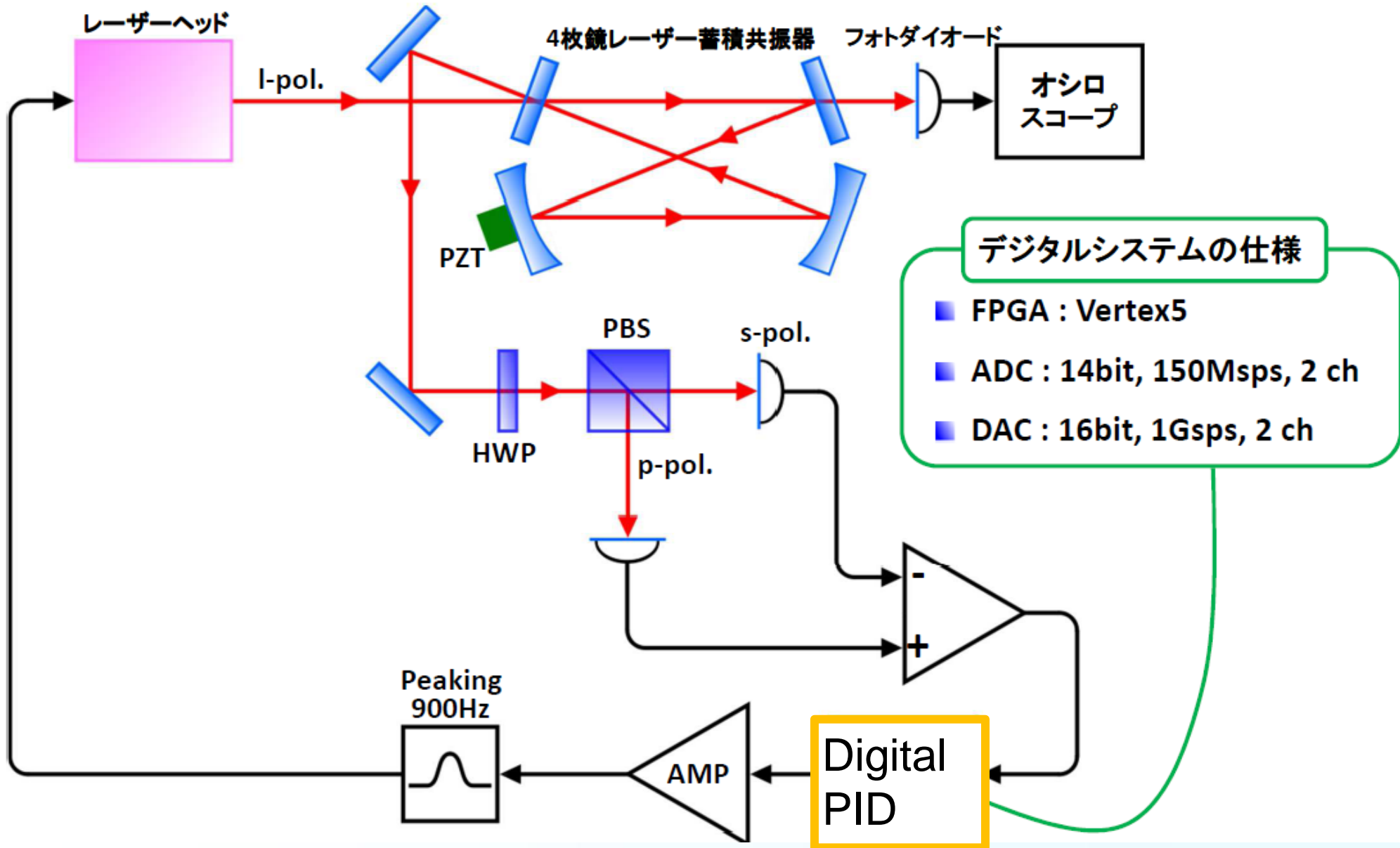
- Possible thermal effect

(unexpected) losses on mirrors
→ distortion

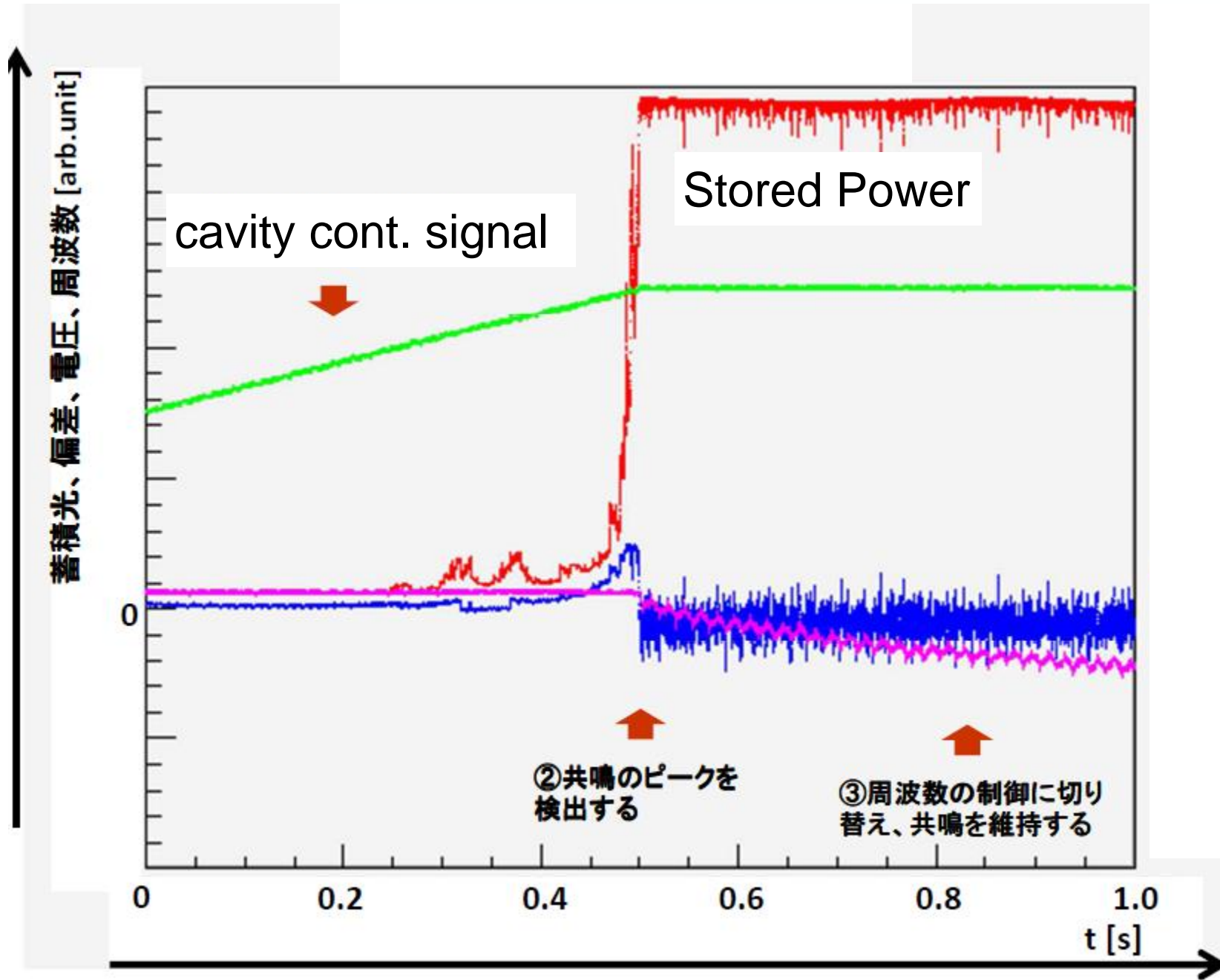
- Profile at the IP

Design: circle
-> alignment

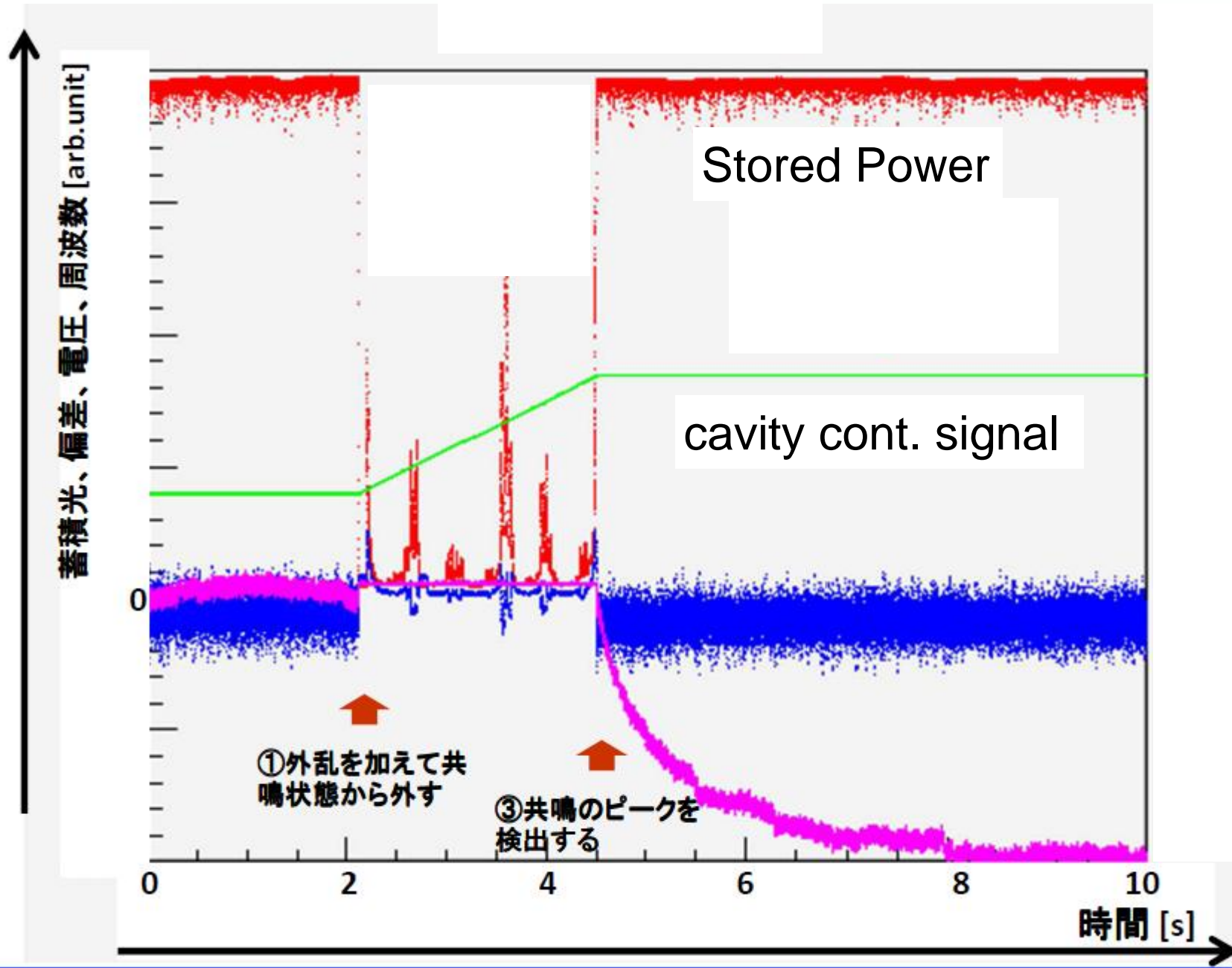
Digital Feedback system



Resonance Finding



Automatic Restoration



Summary and Prospect

- So far
 - 2.6kW stored w/ enhancement of 1230
 - Highly stable $\Delta L \sim 4\text{pm}$
 - vertical laser size at the IP 13 μm
 - 120g/5bunches $\rightarrow \sim 2.6 \times 10^8/\text{sec}$
 - Digital Feedback
- Quantitative understanding
 - Finesse
 - Powers
 - Profile

Summary and Prospect

- Issues
 - Laser profile at the IP
 - possible thermal effect
- Near term plan
 - test Laser profile issue
 - low loss mirrors
 - Higher finesse