# Status of R&D of Optical Cvities at KEK-ATF

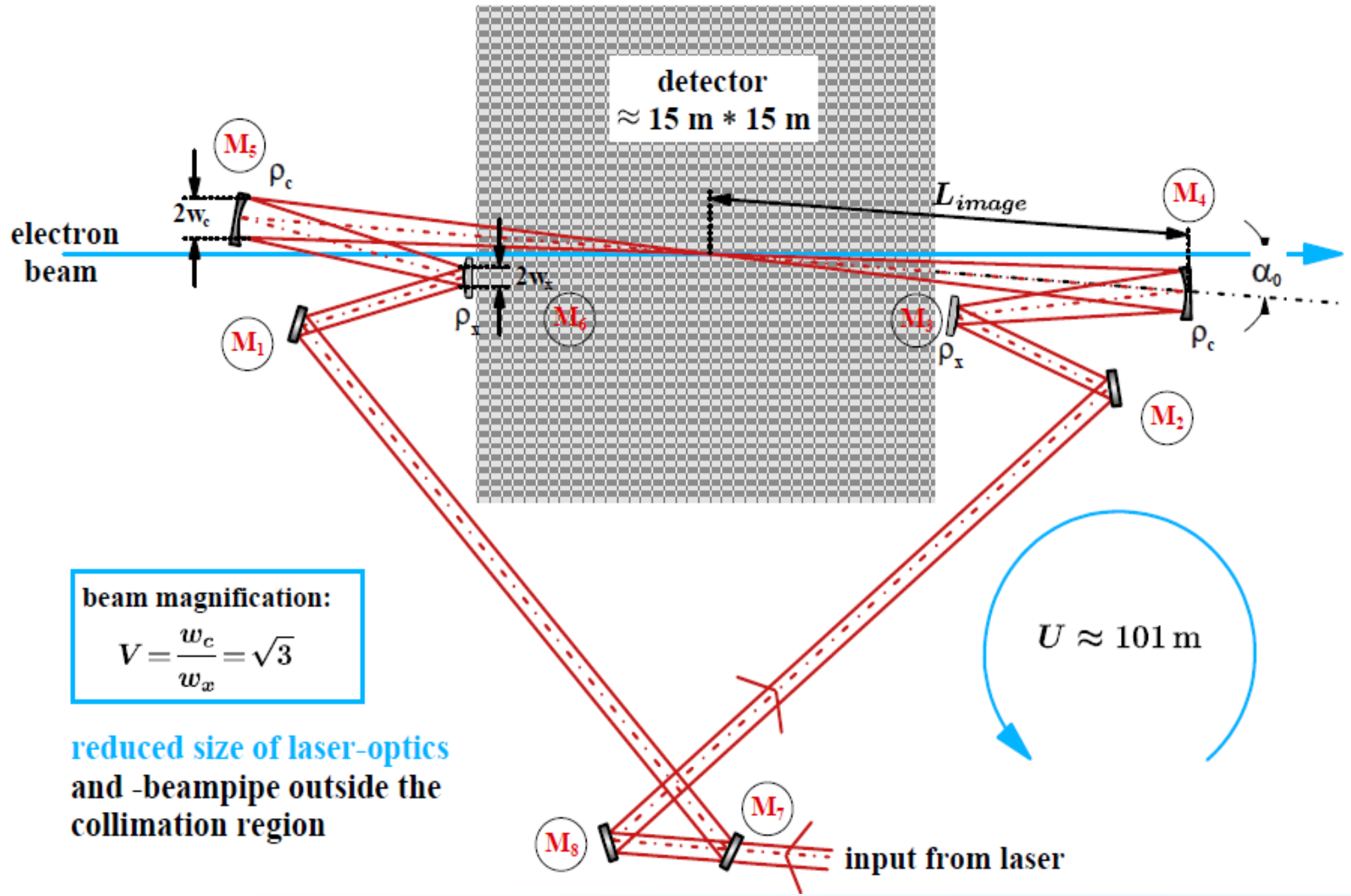
Tohru Takahashi
Hiroshima University
for

**KEK, Hiroshima University**
**LAL (Orsay) in Collaboration withCELIA (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




**beam magnification:**

$$V = \frac{w_c}{w_x} = \sqrt{3}$$

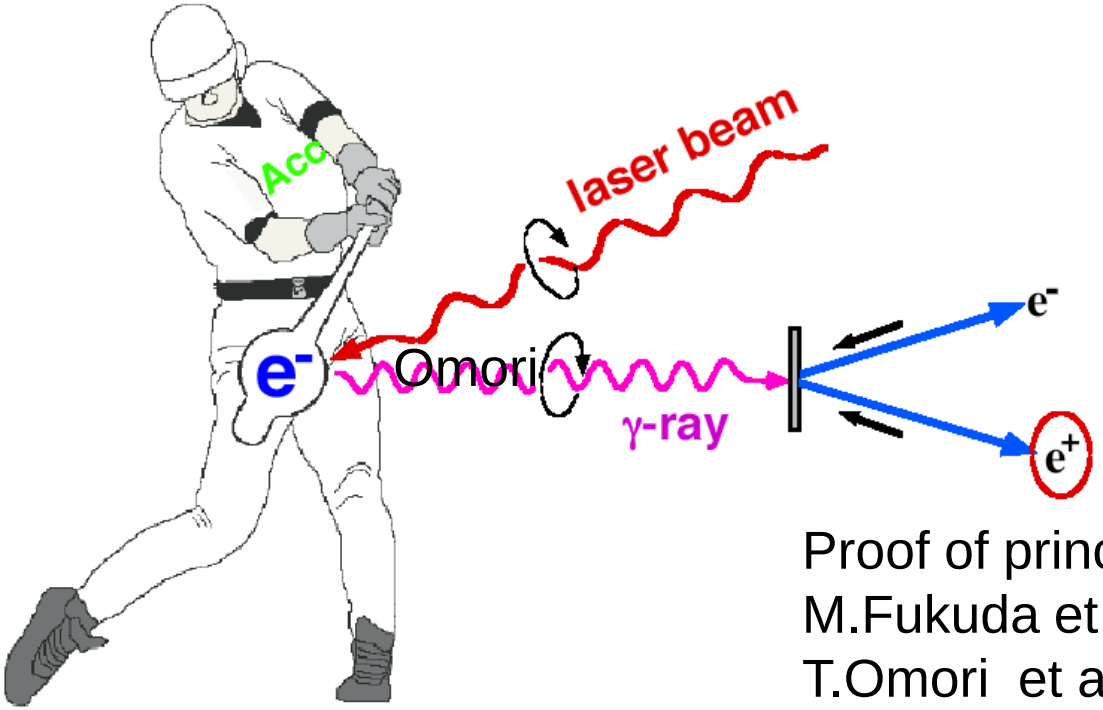
reduced size of laser-optics
and -beampipe outside the
collimation region

# Compton at KEK ATF

- Polarized e+ by laser Compton Scheme

  Ee~1GeV for 10MeV gammas

  controllability of  polarization

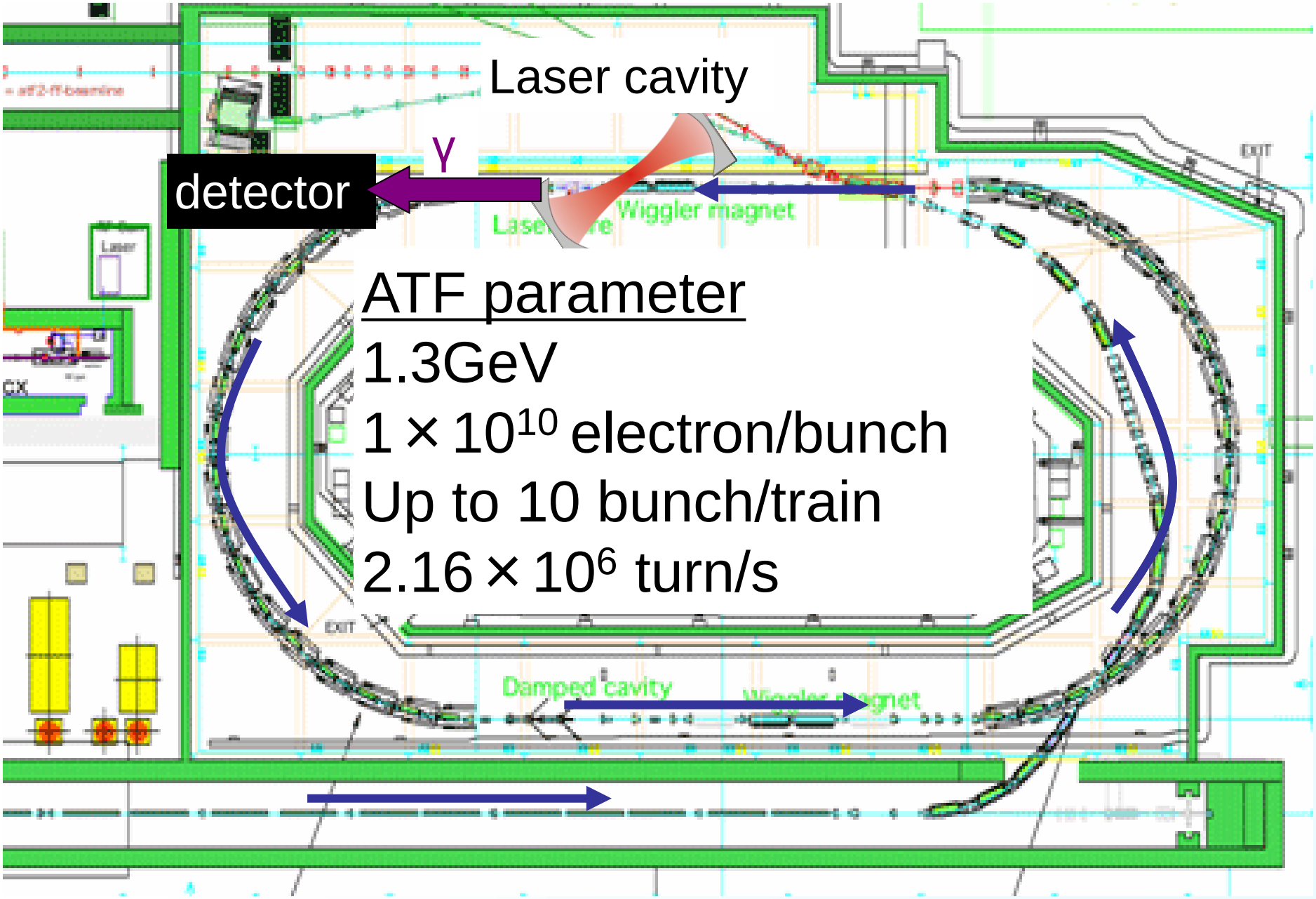



Proof of principle
M.Fukuda et al., Phys. Rev. Letts. 91, 16480(2003)
T.Omori  et al., Phys. Rev. Letts. 96, 114801(2006)

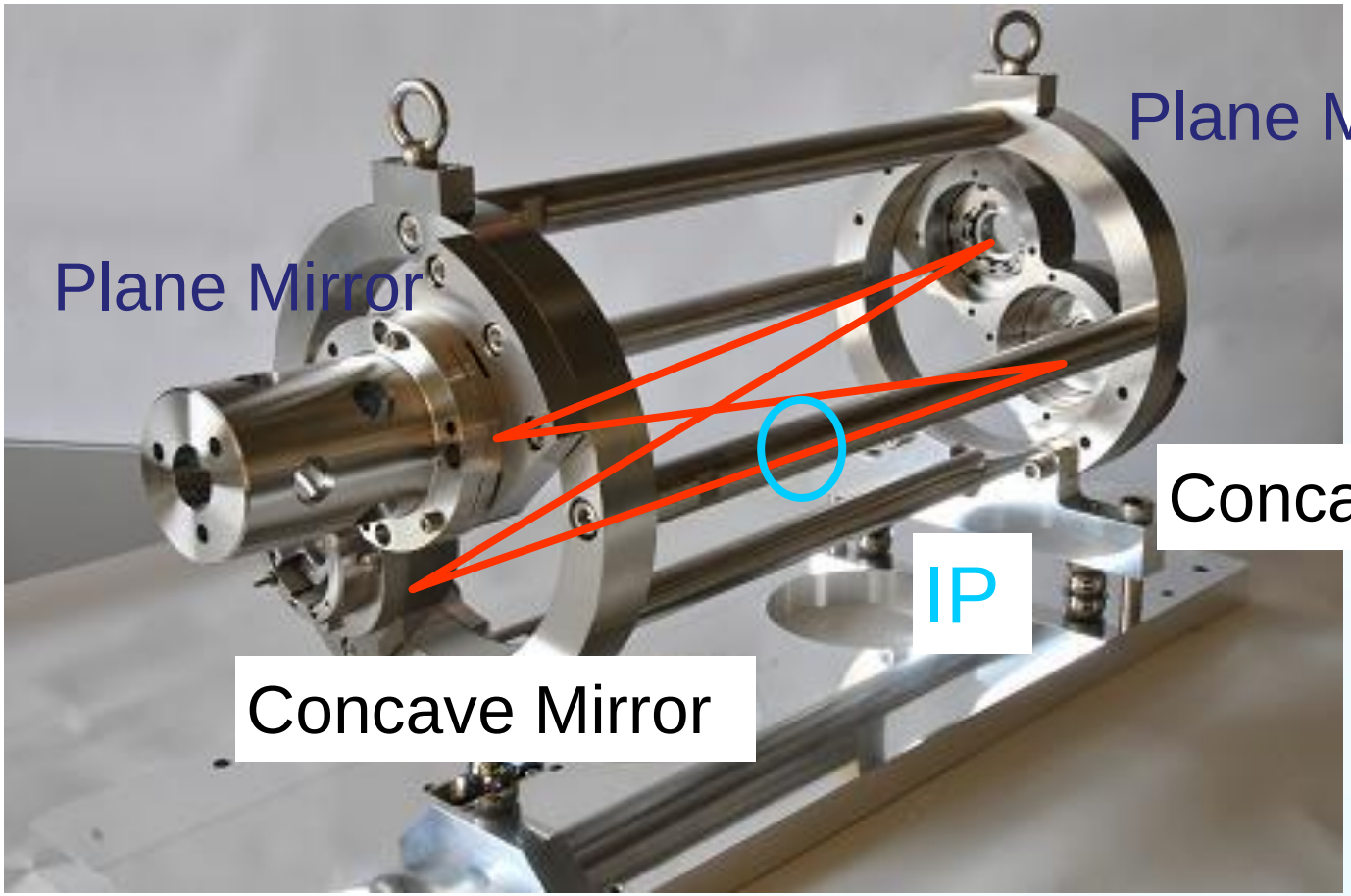
Toward the positron sources

—> increase intensity of γ rays

# Setup at the KEK-ATF

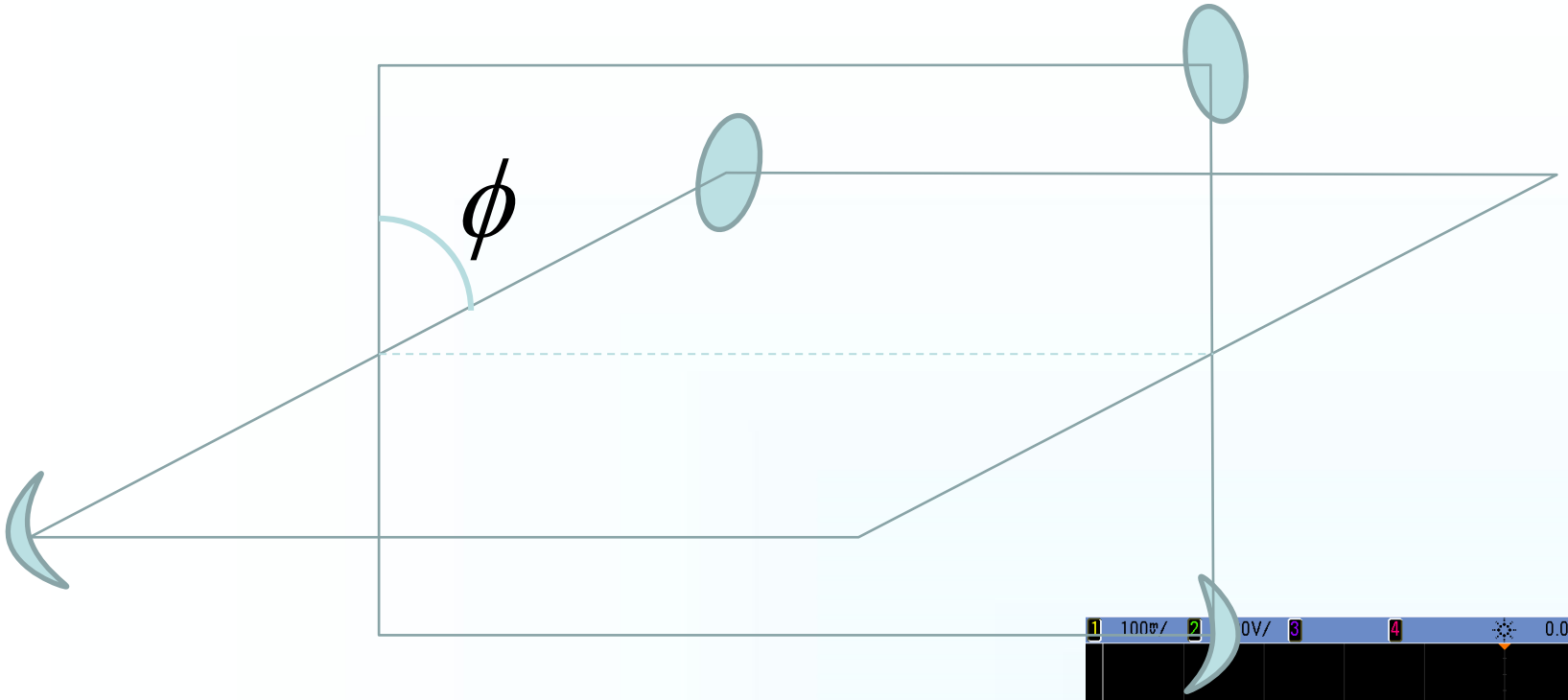


# The Optical Cavity




Main Parameters
Circumference:1.68m
Finesse:4040(Measured)
Power Enhansement:1230

# 3Diensional 4Mirror Cavity





Resonates only for Circular polarization
Left/Right separately

Optical path

# 4 mirror cavities are at the ATF

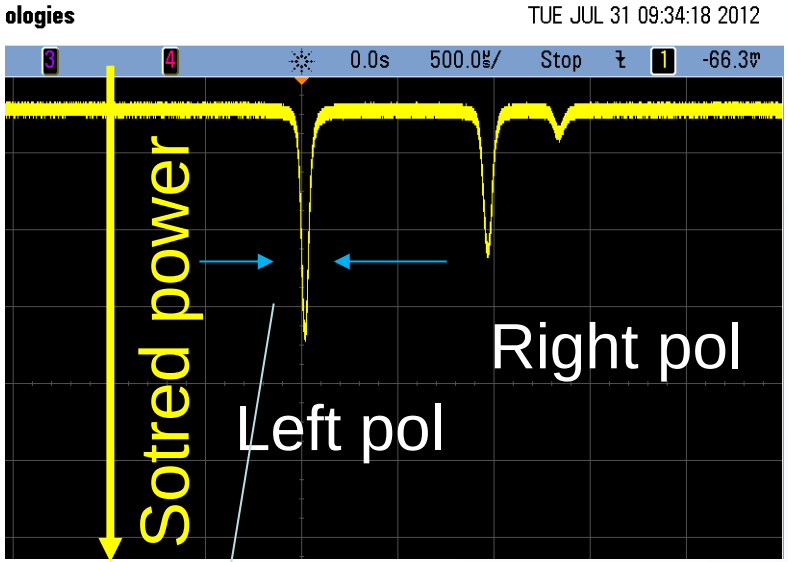
KEK-Hiroshima
installed 2011

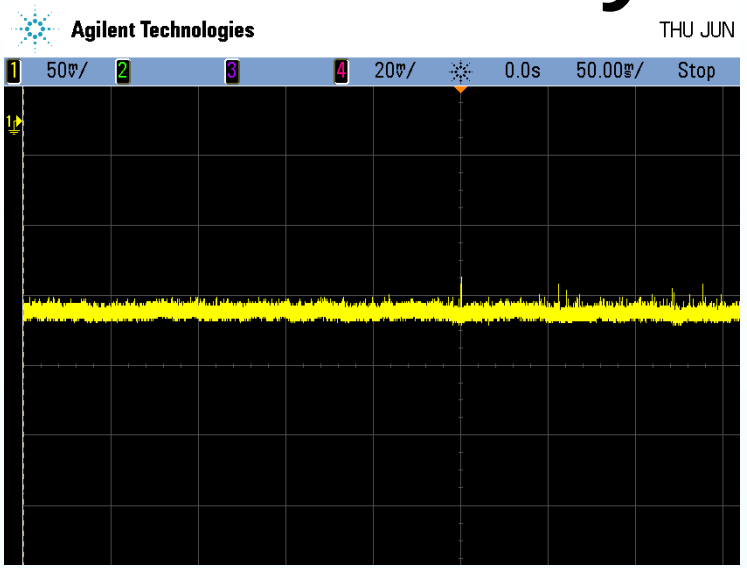
relatively simple control system
employs new feed back scheme

LAL-Orsay
installed summer 2010

sophisticated control
digital PDH feedback

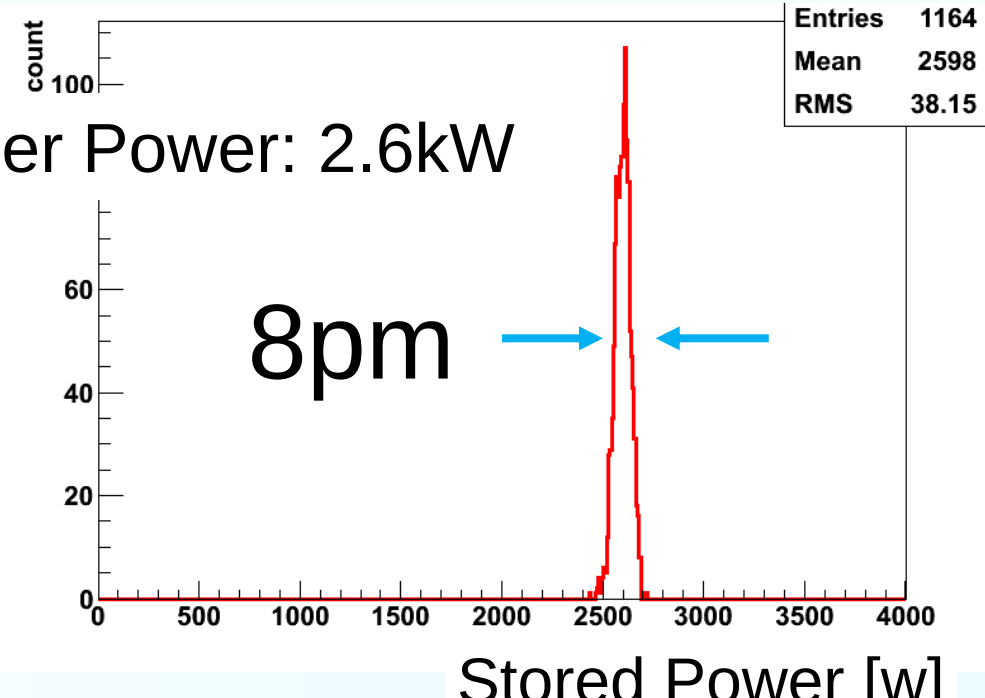
# Stored Laser Power in the cavity



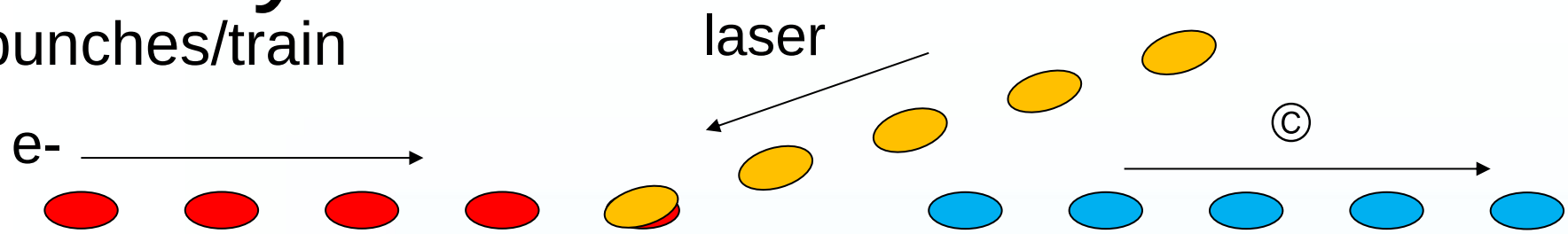

FWHM: 110pm

Laser Power: 2.6kW

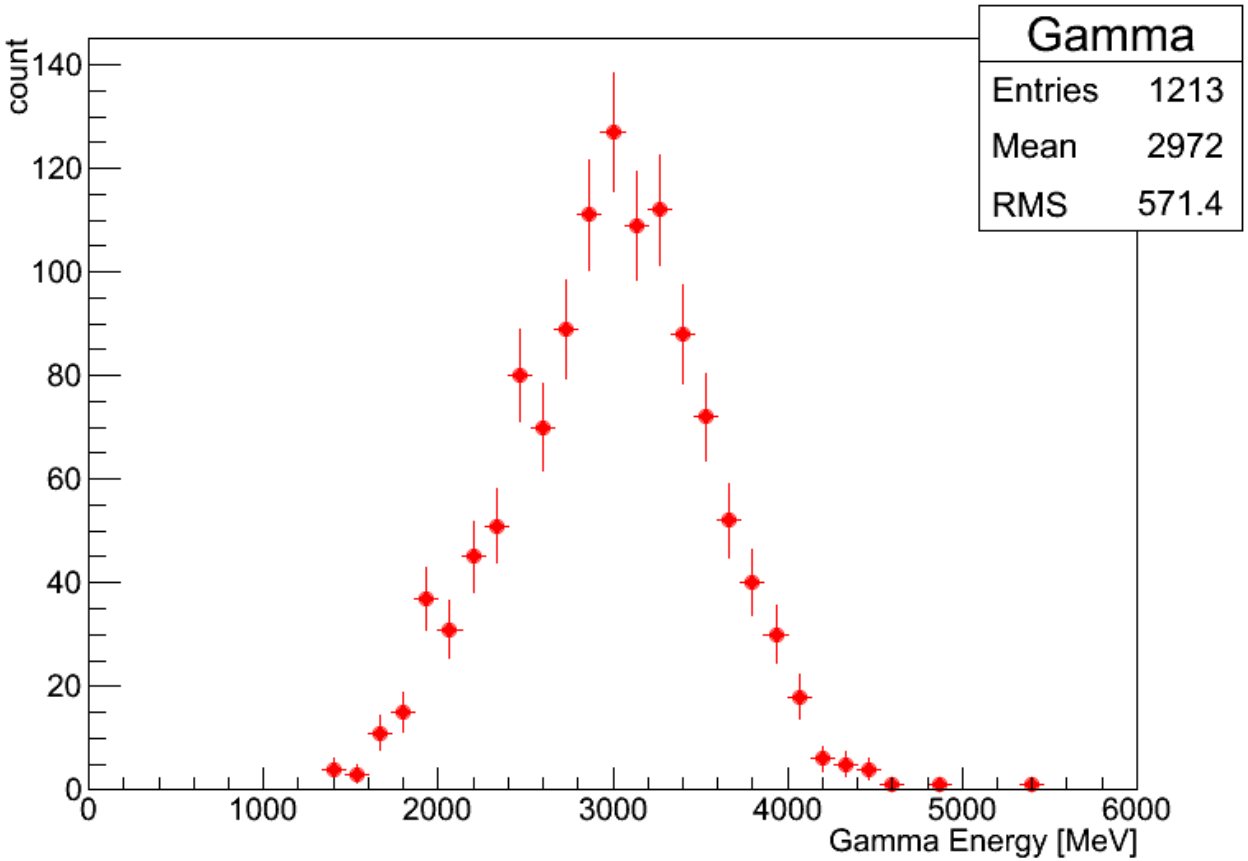


# ©ray Generation

5bunches/train




5.6ns




2970±20 MeV

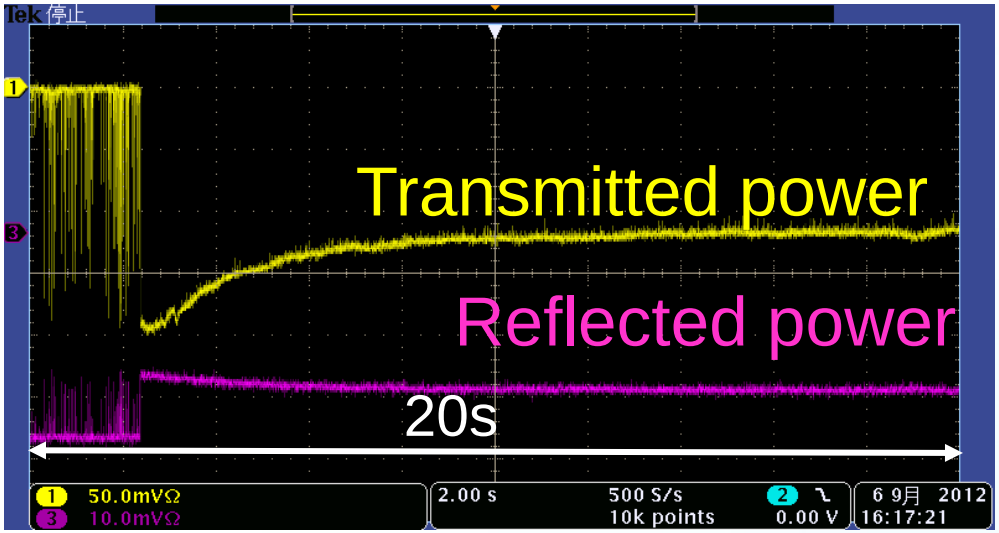
⇒ ~120γs/train

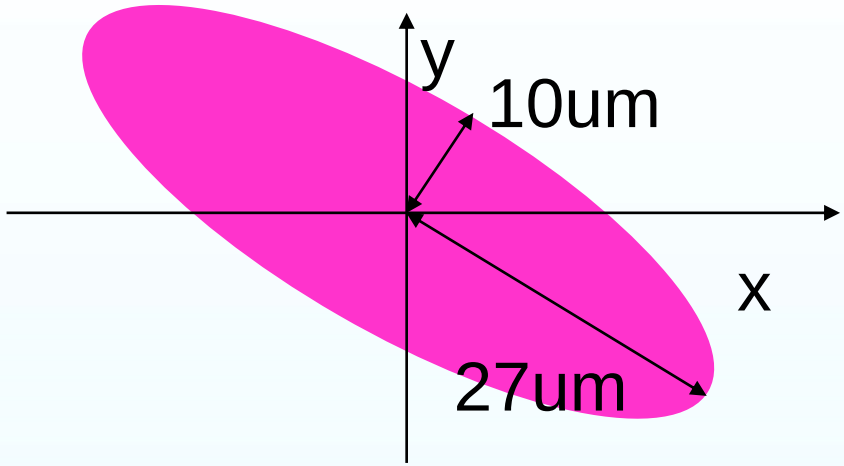
ATF 2.16MHz

~2.6×10$^8$/sec

E©[MeV]

# Issues



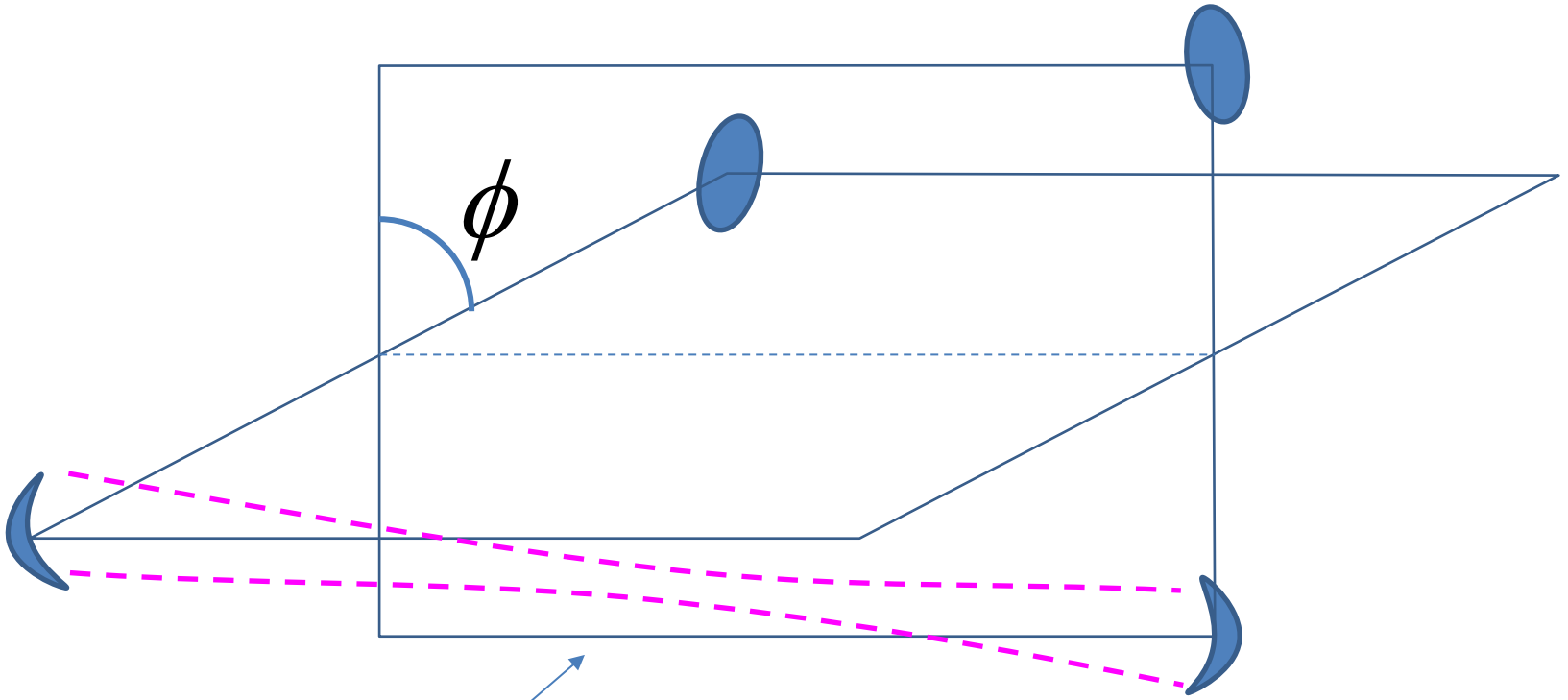

- Possible thermal effect

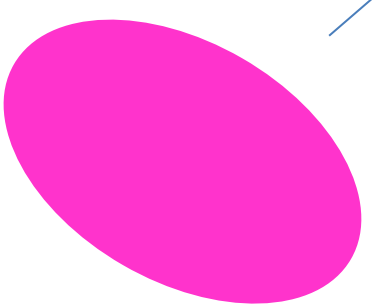
(unexpected) losses on mirrors
→distortion

- Profile at the IP

Design:  circle

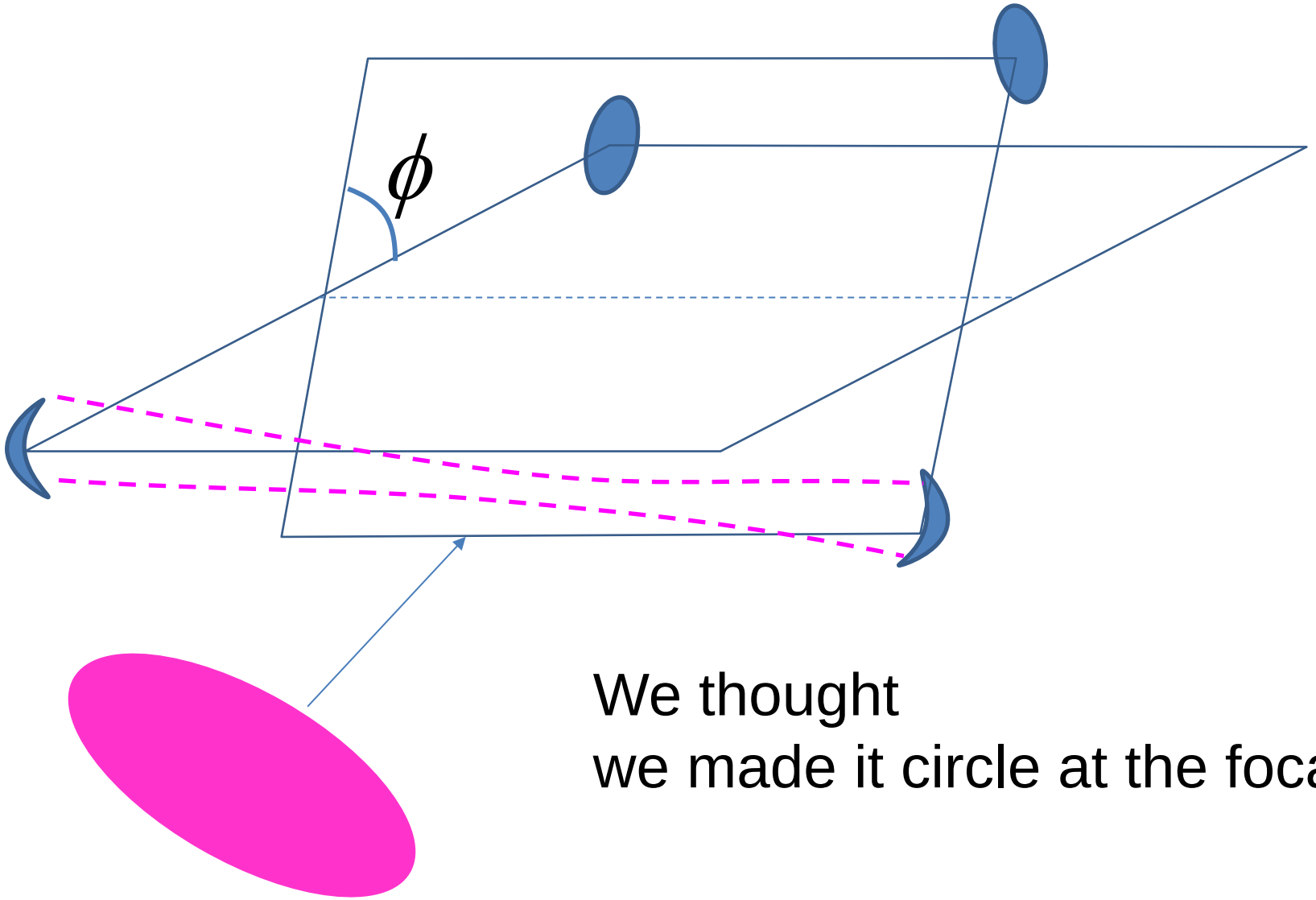
# Beam Profile in the cavity



Profile at the focal point depends on $\phi$

# Beam Profile in the cavity

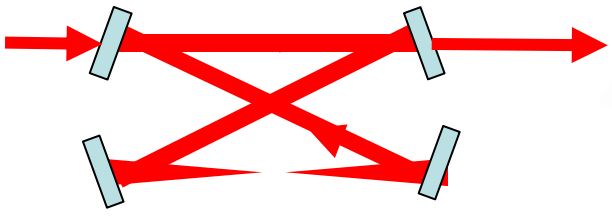


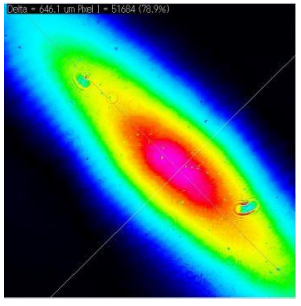

We thought
we made it circle at the focal point,,,,,

# Propagation of the laser light

- Calculation
  - transfer matrix
  - Propagation of EM waves in the cavity
- Systematic measurements
    - $\phi = 87.5^\circ, 90, 92.5$

# Measuremennsof the profiles

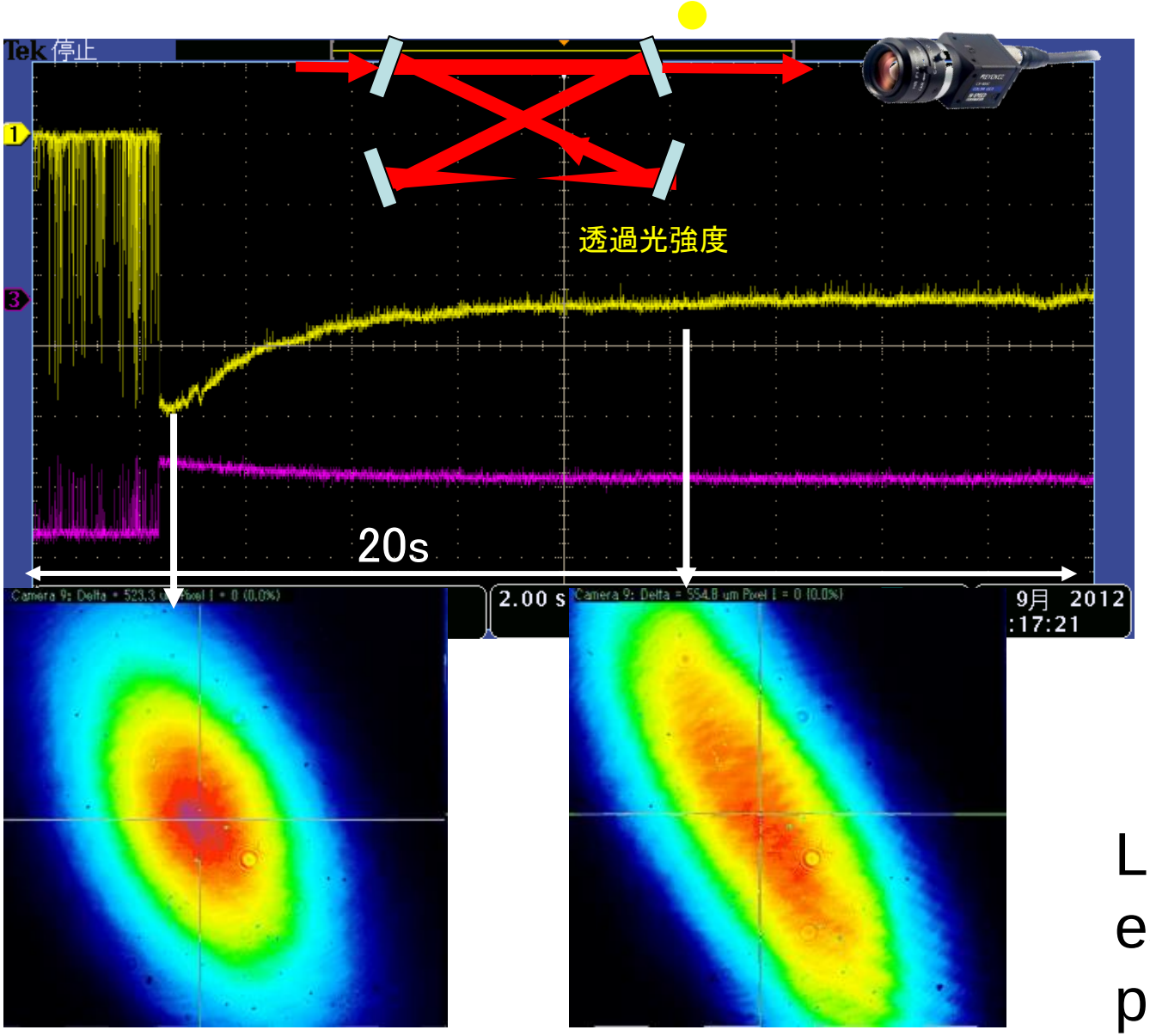




| | | $\phi = 87.5°$ | $\phi = 90°$ | $\phi = 92.5°$ |
|---|---|---|---|---|
| Calculation | Major axis（μm） | 1 | 941.4 | 939.6 | 937.5 |
| | | 2 | 938.7 | 941.6 | 939.5 |
| | Minor ai | 1 | | | 775.7 |
| | | 2 | | | 919.9 |
| | Angle Relative to 90 | 1 | +1.17 | | -1.16° |
| | | 2 | +0.28° | | +35.13° |
| Measured | Major axis | | 944 | 937 | 939 |
| | Minor aixs | | 532 | 546 | 507 |
| | Angle Relative to 90 | | -0.9° | | -9.1° |

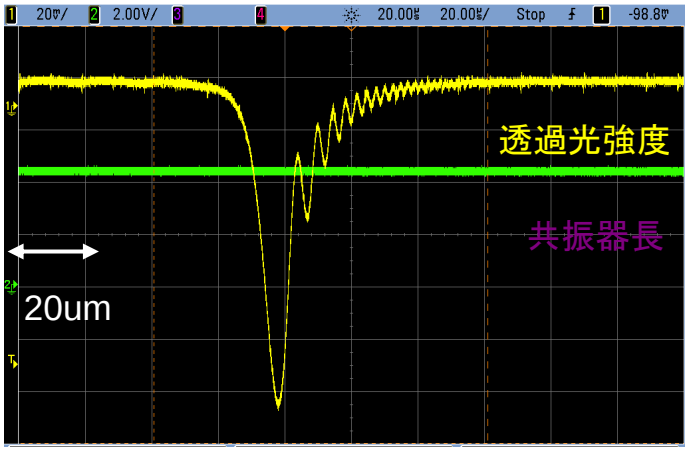
still working on it

# Deformation of Mirrors




Low loss mirrors are essential to increase power

# Cleaning the mirrors




Before

$$R = 0.999846 \pm 0.000003 \qquad \text{(Loss : 50ppm)}$$

After

$$R = 0.999864 \pm 0.000003 \qquad \text{(Loss : 30ppm)}$$

# Summary

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

# Future prospect

- Try high reflectivity mirror
  - w/ careful handling
  - Trying 3000~5000  power enhancement this year
    -> more than 10,000 in next a few years

- Low loss mirrors
  - collaboration with NAO (gravitational wave guys)
  - careful investigation of commercial mirrors
  - develop mirrors (substrates) by ourselves?