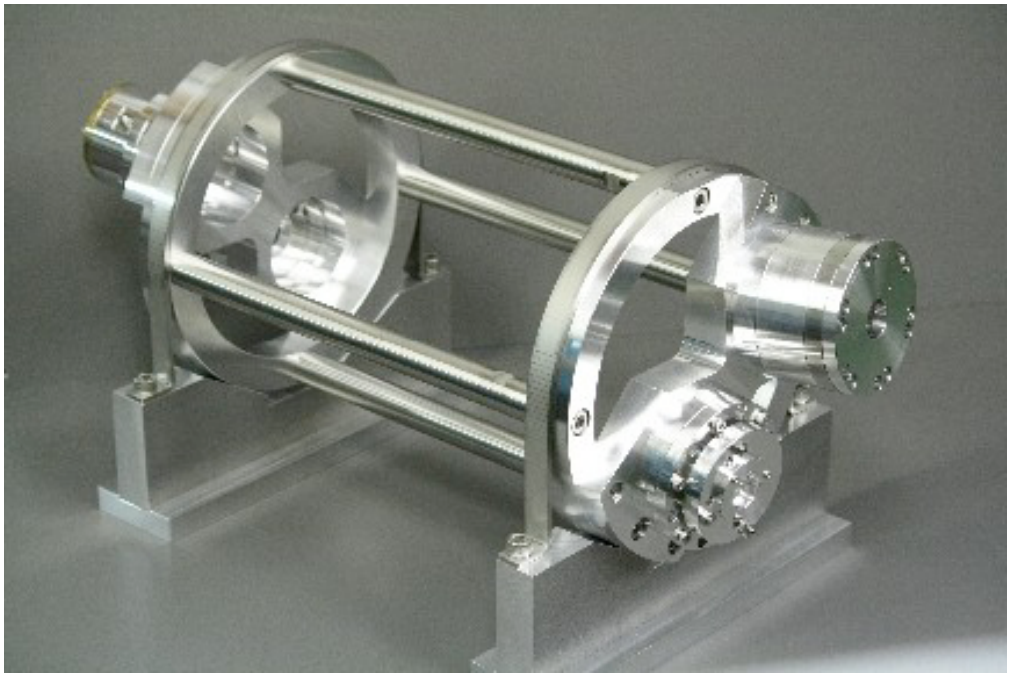
Compton Experiment at ATF



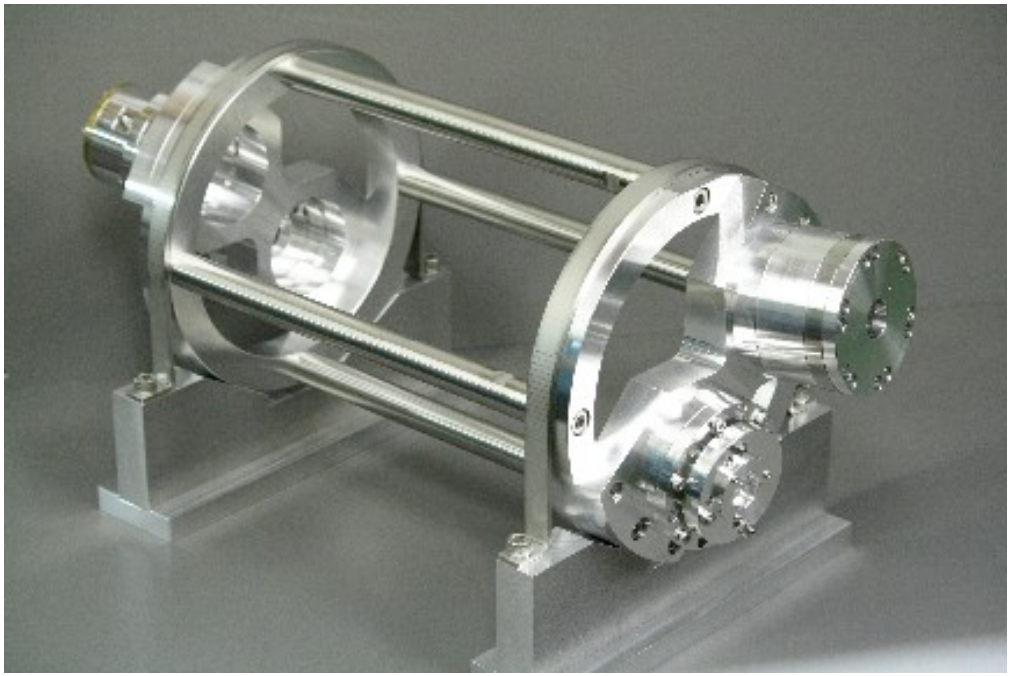
T. Takahashi (Hiroshima) / T. Omori (KEK)
for collaborators

LCWS10 28-March-2010

Two Prototype Cavities

2-mirror cavity (Hiroshima / Weseda / Kyoto / IHEP / KEK)

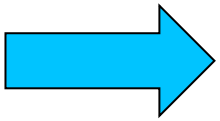
4-mirror cavity



moderate enhancement
moderate spot size
simple control

high enhancement
small spot size
complicated control

demonstration of γ ray gen.
accum. exp. w/ cavity and acc.

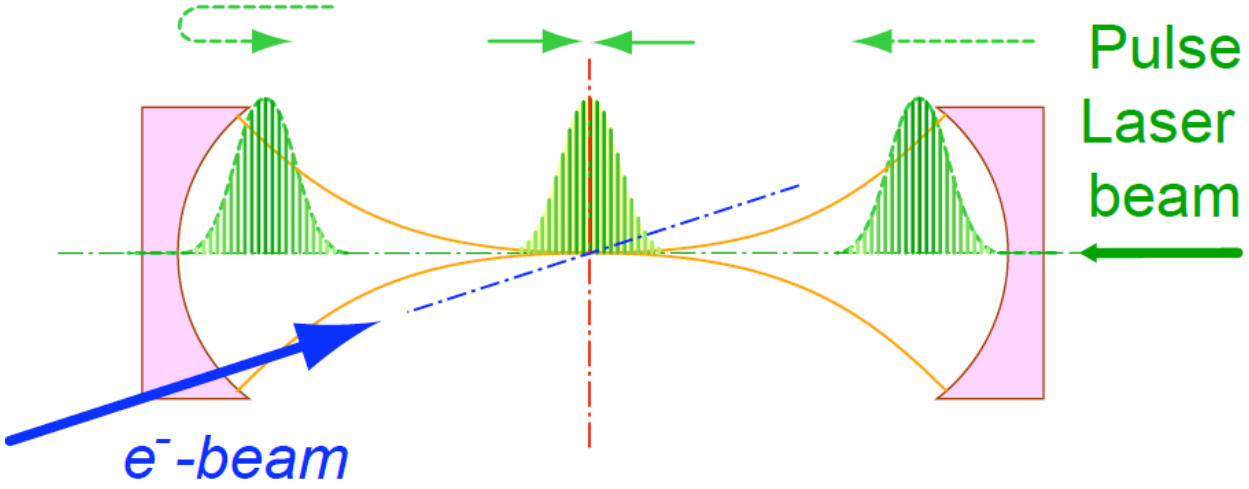


intense γ ray generation

STATUS OF THE 2 MIRROR CAVITY

Experimental R/D in ATF

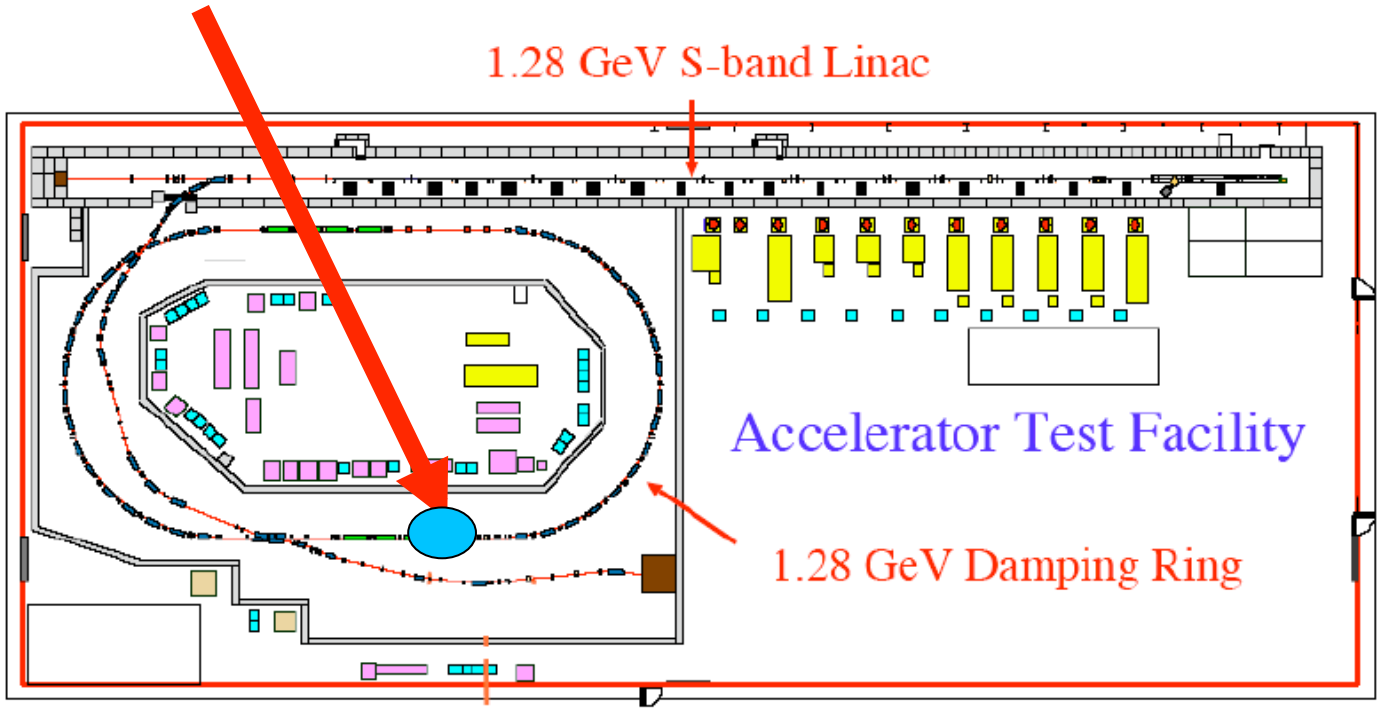
Hiroshima-Waseda-Kyoto-IHEP-KEK



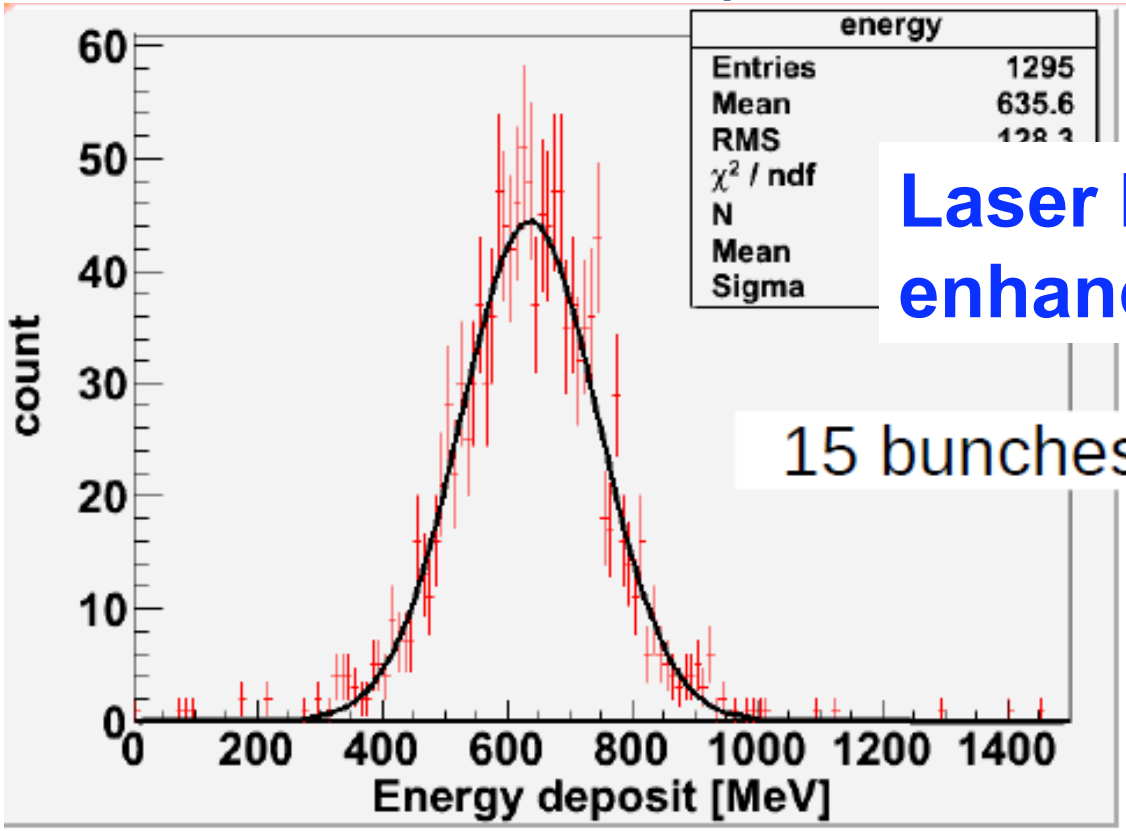
prototype
2-mirror cavity

L_{cav} = 420 mm

Put it in ATF ring



Result as of 2008 (Reported TILC09)



Laser Power ~500W
enhancement 250

15 bunches / train

27 gamma ray / crossing

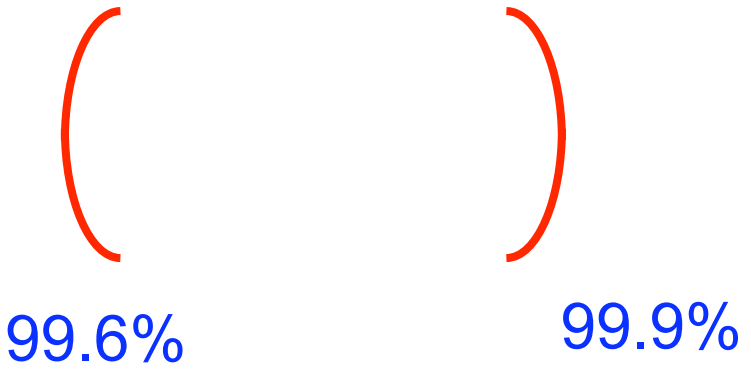
Next step

more power enhancement

bunch by bunch observation

AFTER TILC09

- One of the Mirror was replaced with the higher reflectivity one
  - 99.6% -> 99.9%
  - power enhancement
    - 250 -> ~750
  - more precise controll required (~0.1nm)



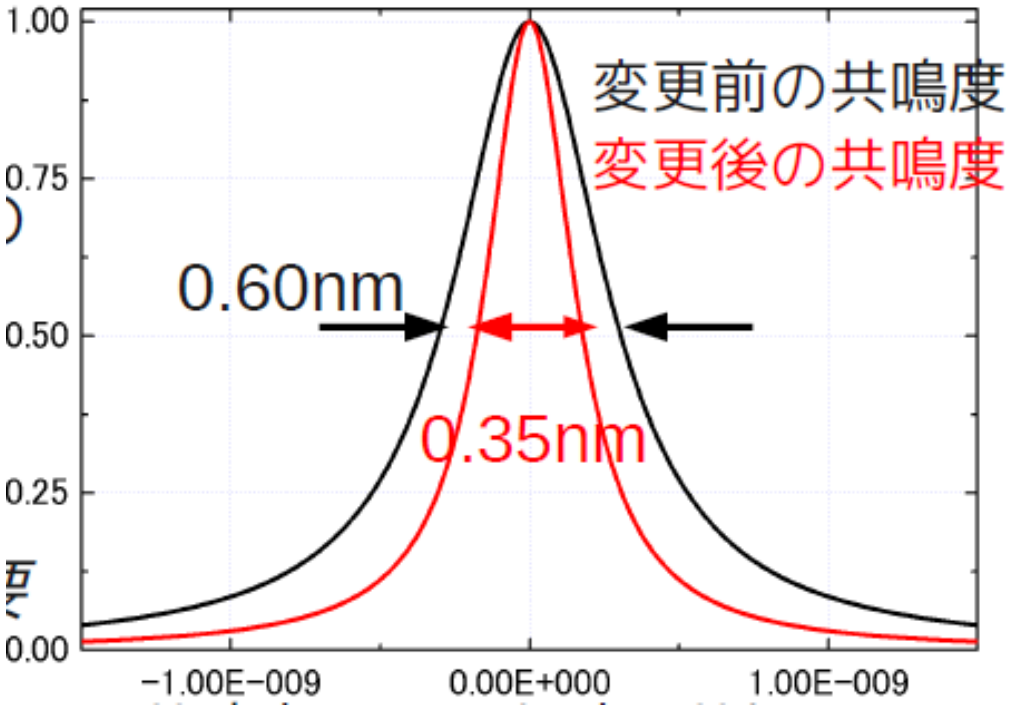
- Status of the cavity w/ new mirror
  - now in ATF DR
  - hope to get 3 times more photons before summer shut down

More enhancement
More precise control

- (99.64%, 99.64%) to (99.64%, 99.94%)
- enhancement: 250 to 760

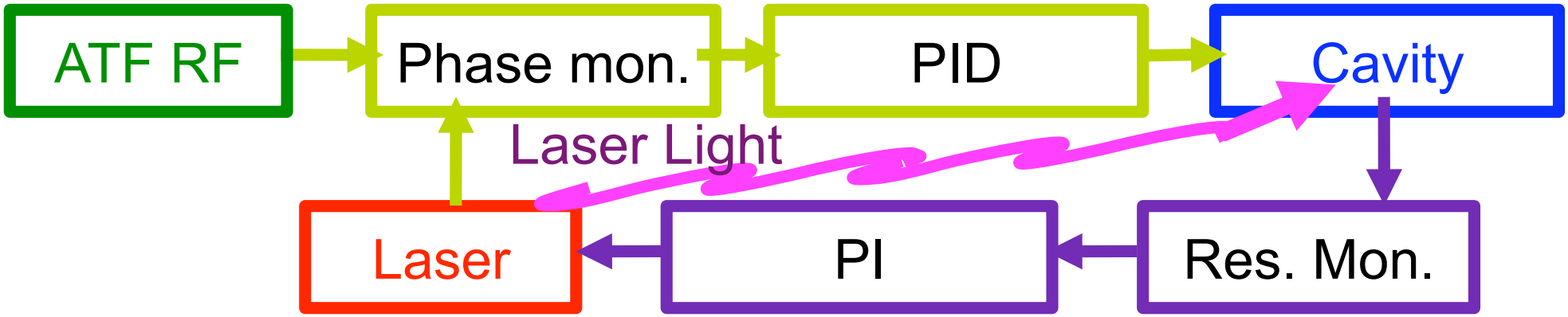
Witdh of resonant peak got down to 0.35nm from 0.60nm

More precise(~faster) control of cavity



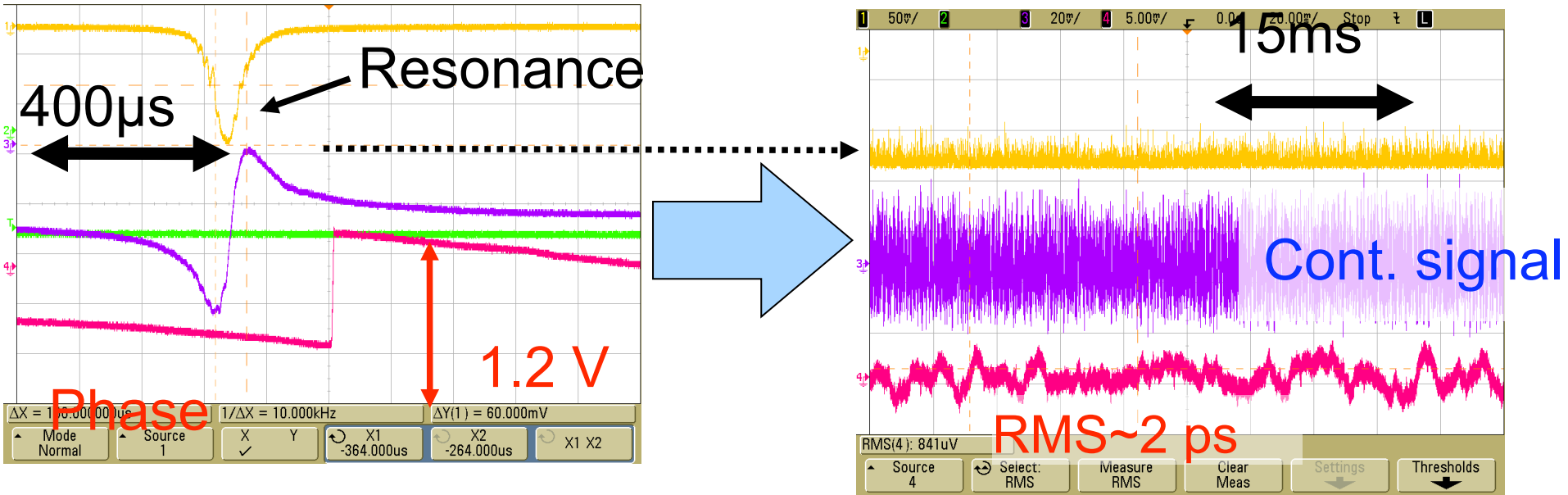
cavity length [nm]

Feed back system in 2008

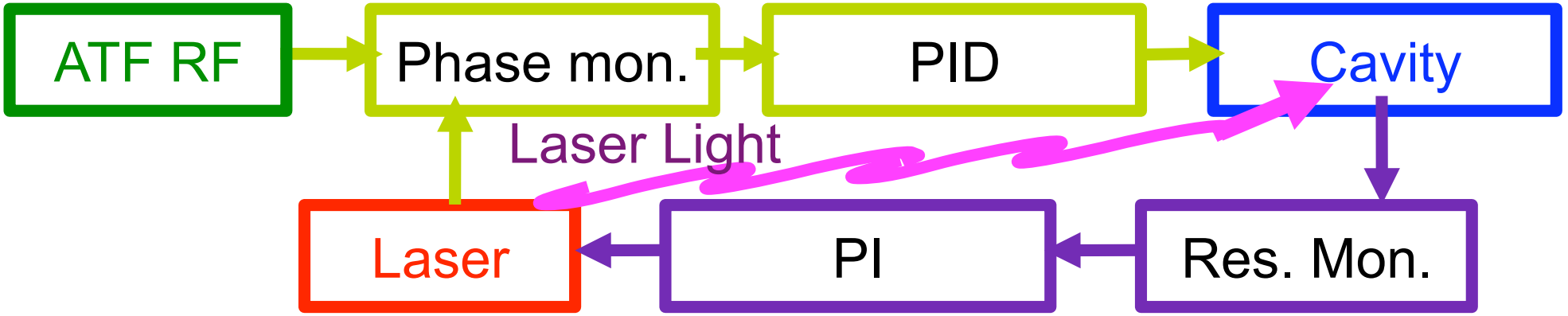


Control:
Laser to keep resonance
Cavity for timing synchronization

Keeping resonance at
250 enhacement
with timing jitter ~2ps



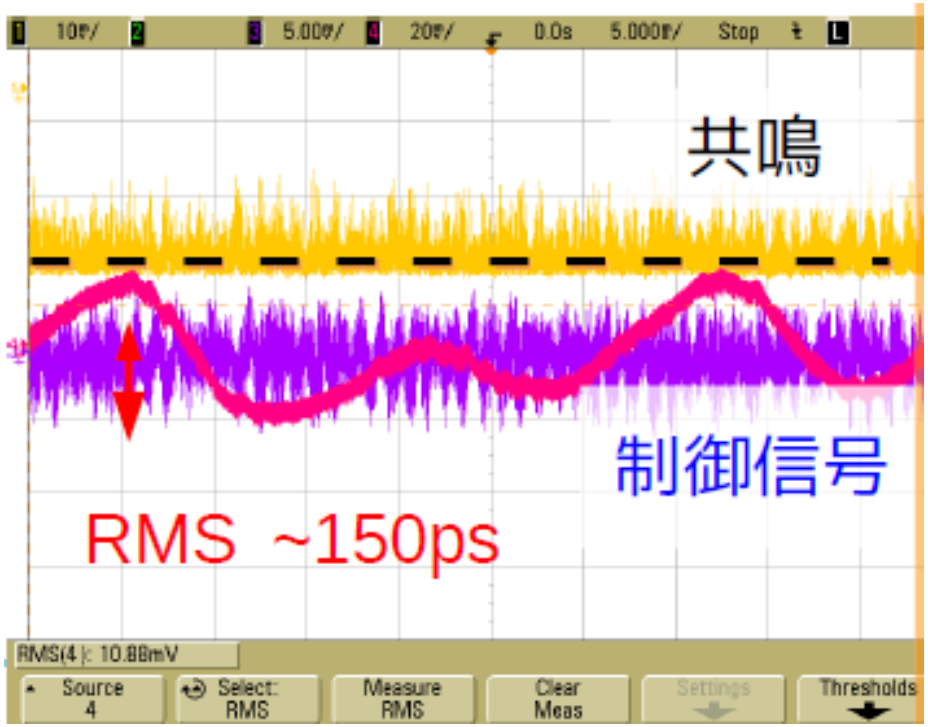
Initial performance with 760 enhancement



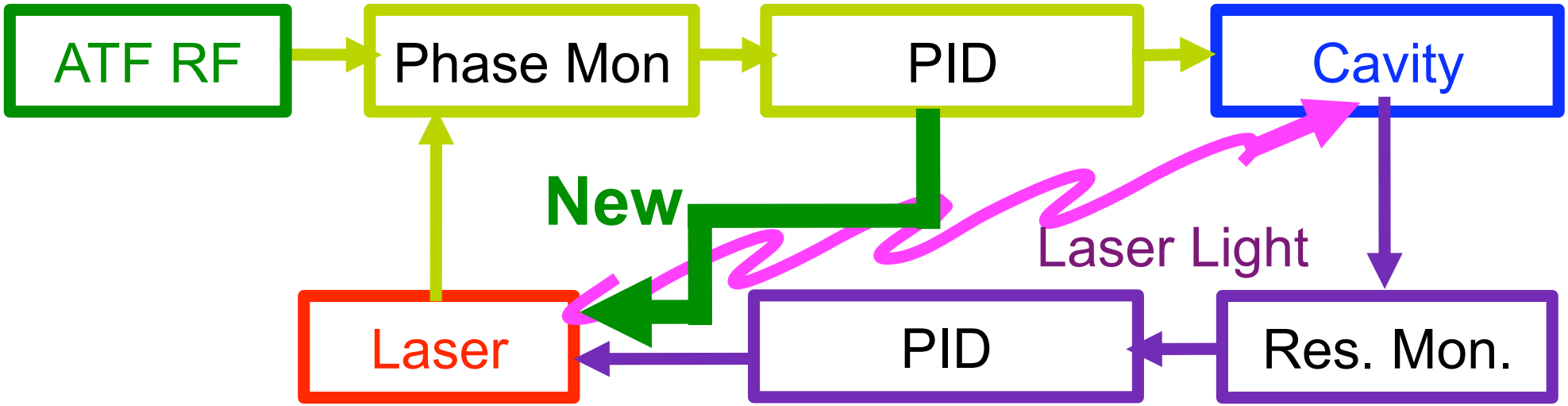
Faster feed back to laser to keep resonance

Larger fluctuation of laser timing

timing control could not follow

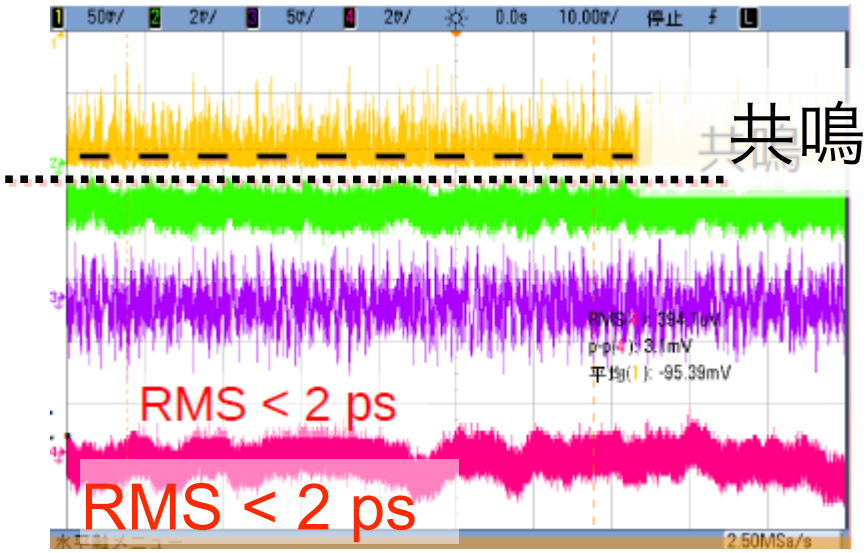


New feedback system



New feedback control
+ improve emviromnet

Timing jitter is now < 2ps



W/ Larger enhansement cavity in 2009

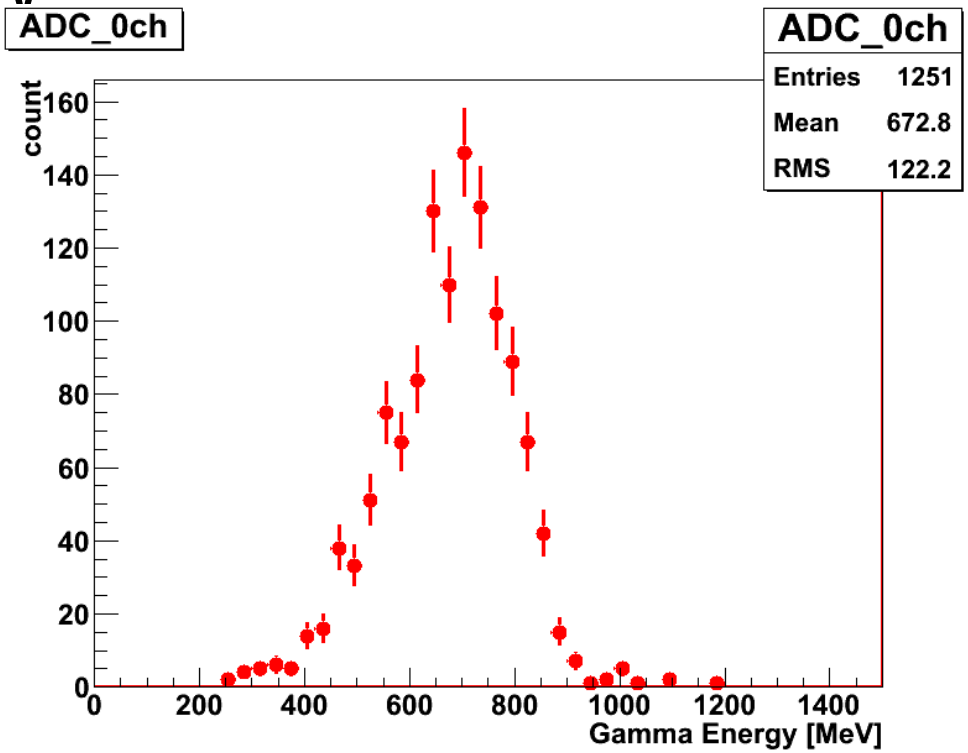
After, extensive studies;

Power enhancement of the cavity ~ factor 3

Laser power 500W to 1.48kW

- 10.8γ/train at 1 bunch (2.2mA)
- 26.8γ/train10cunches(6.7mA)

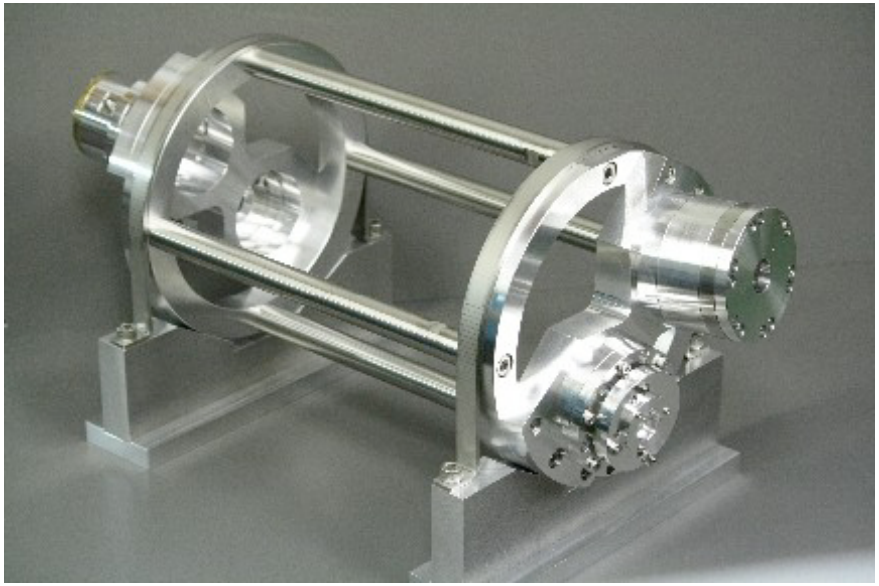
The electron beam was not tuned enough in 2009



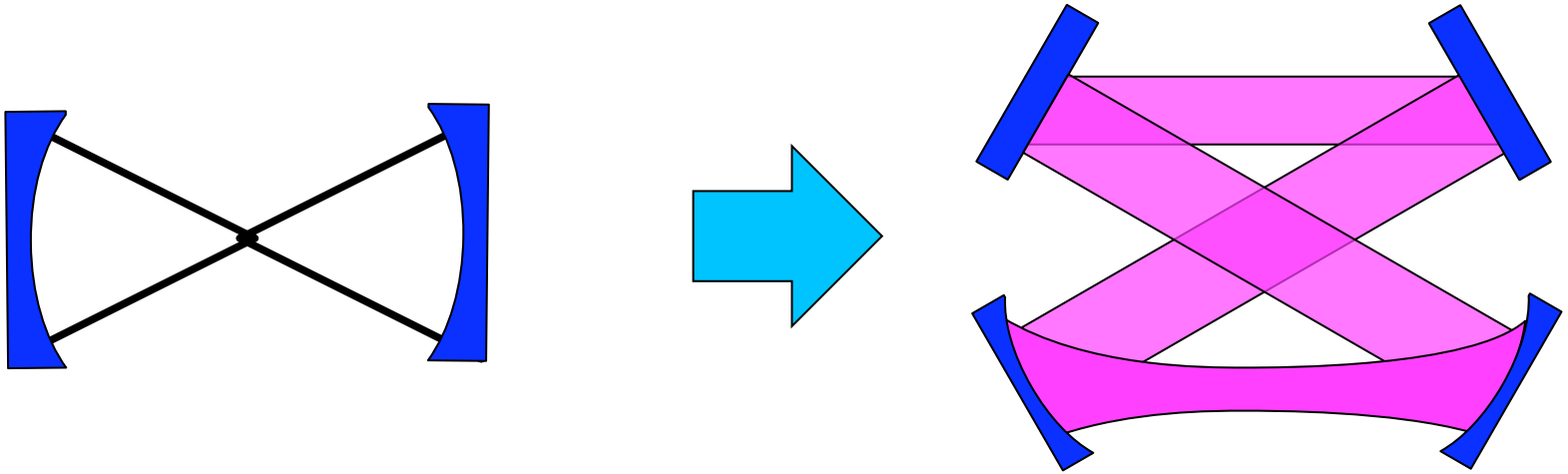
demonstration of 3 times more g by beam tuning

bunch by bunch observation soon

4 MIRROR CAVITY

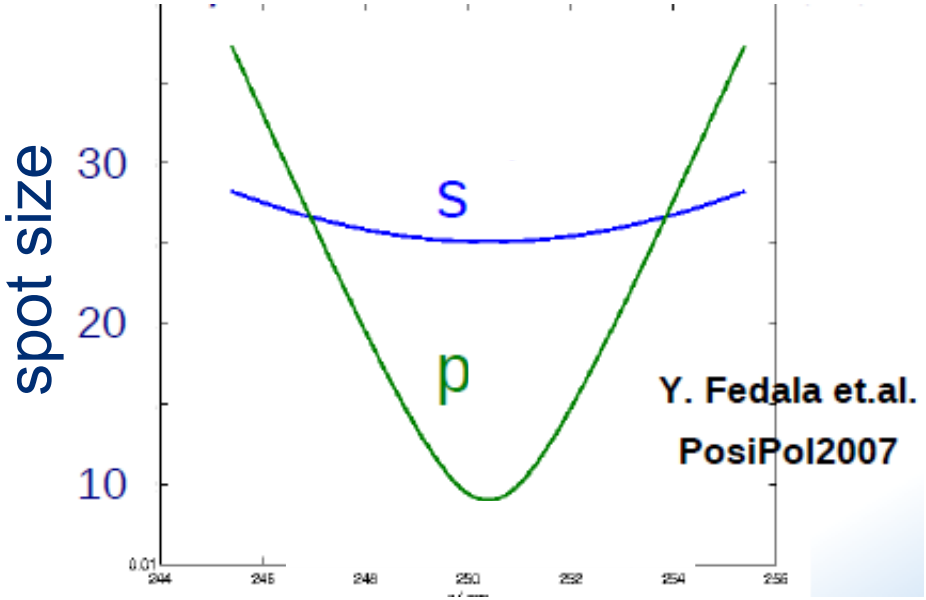


to get higher enhancement and smaller beam waist



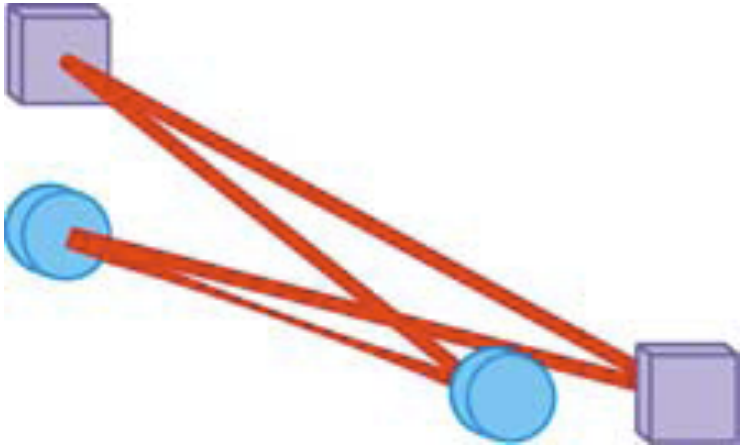
2D configuration

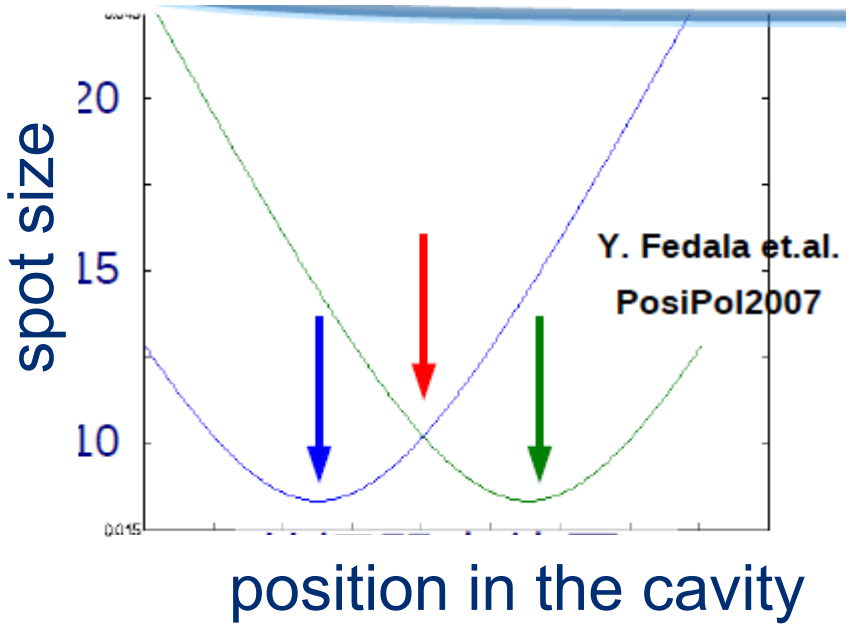
2D 4mirror cavity has astigmatism.



3D configuration

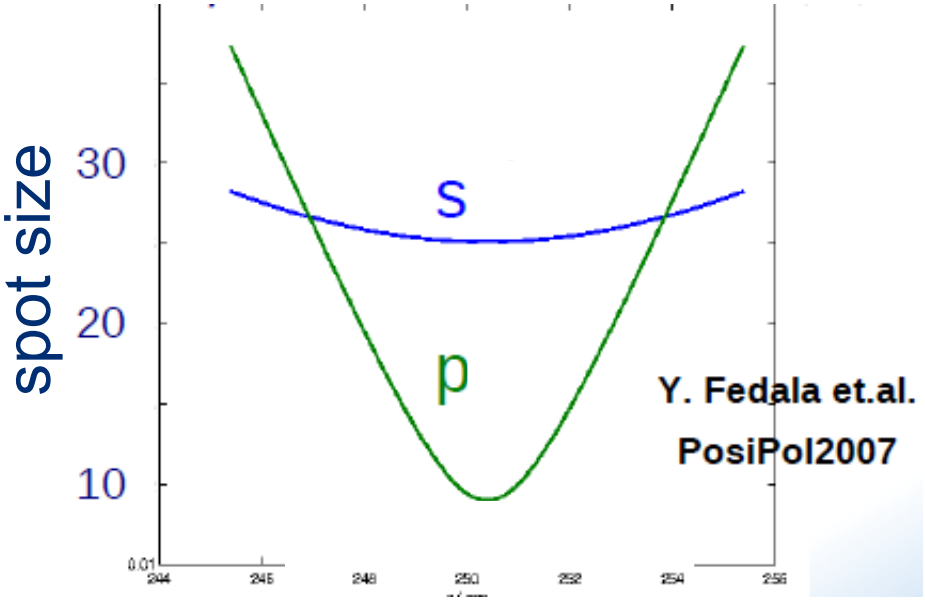
go to 3D config. to avoid astgmatism





2D configuration

2D 4mirror cavity has astigmatism.

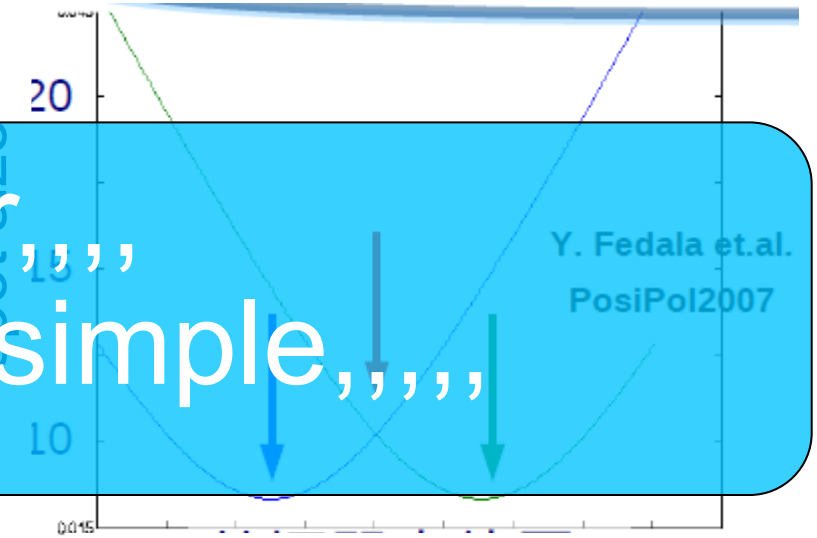


position in the cavity

3D configuration

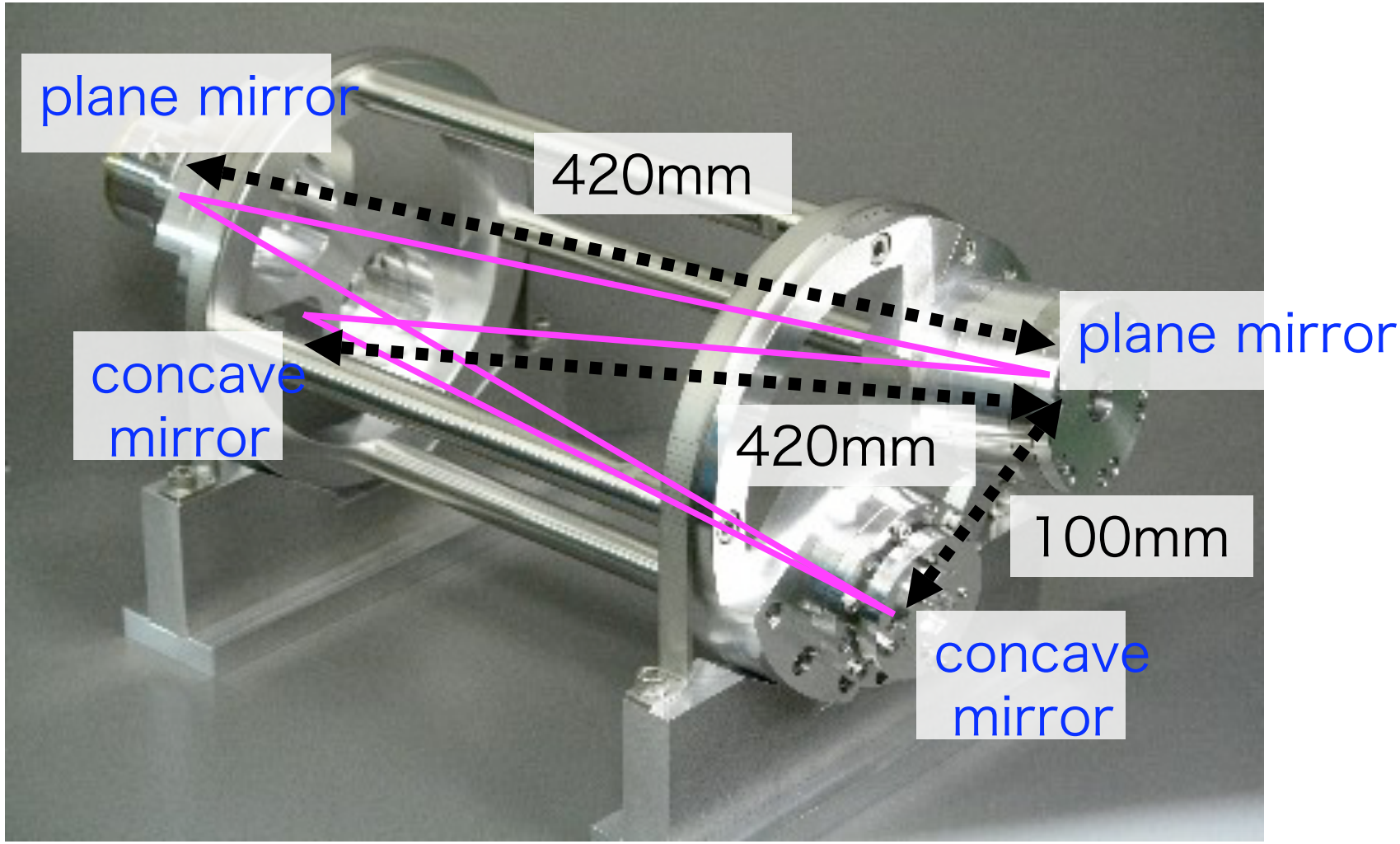
go to 3D config. to avoid astgmatism

However,,,,
Life was not so simple,,,,,



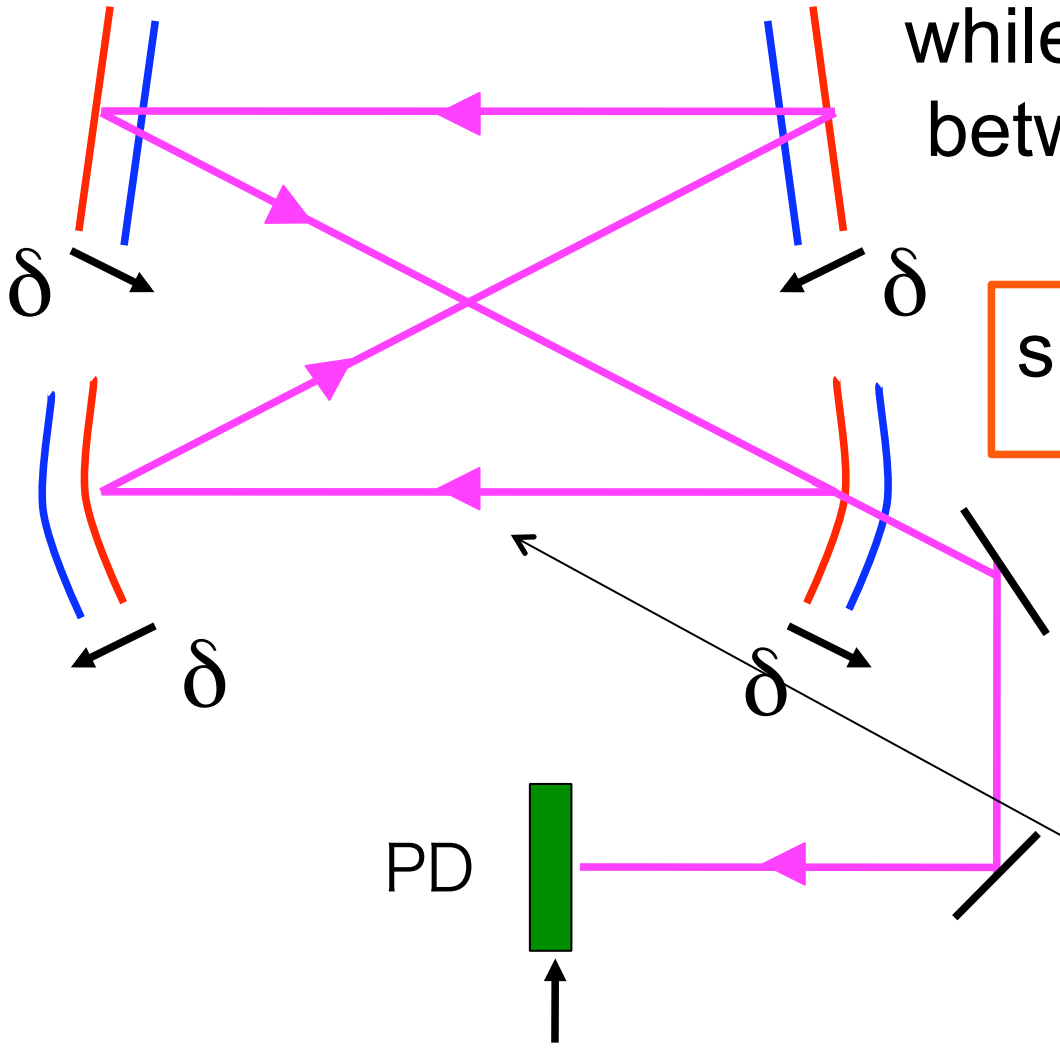
position in the cavity

A prototype 3D4M cavity



Property of 4M cavity

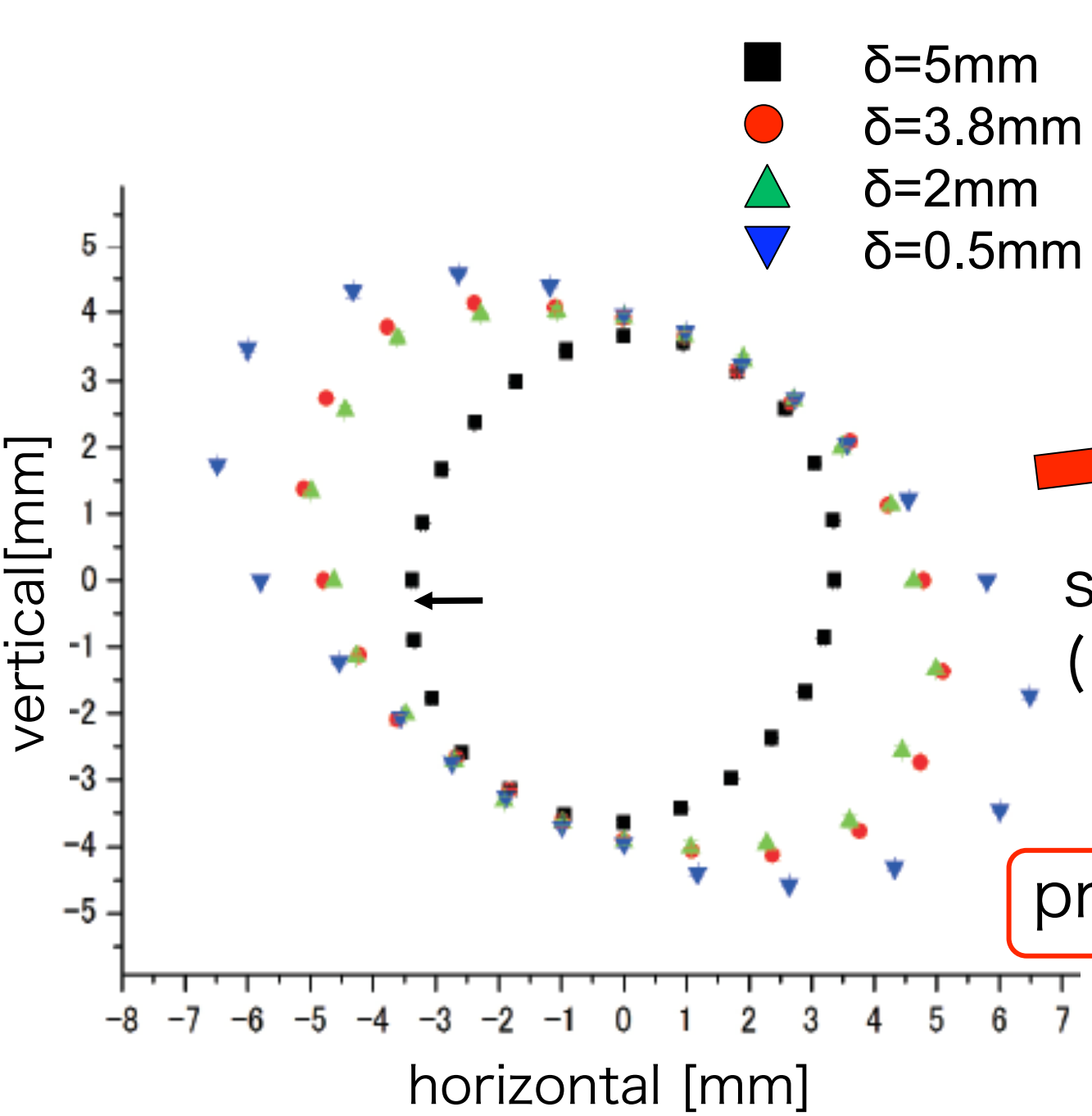
δ: keeping circumference constant while changing distance between mirrors

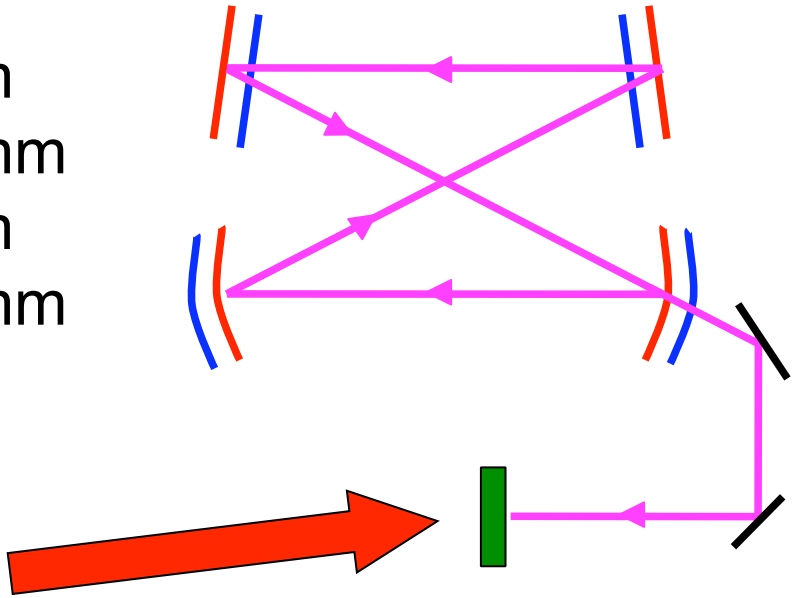


smaller δ : smaller beam waist

measure beam profile here-->estimate beam size in the cavity

Profile of transmitted light

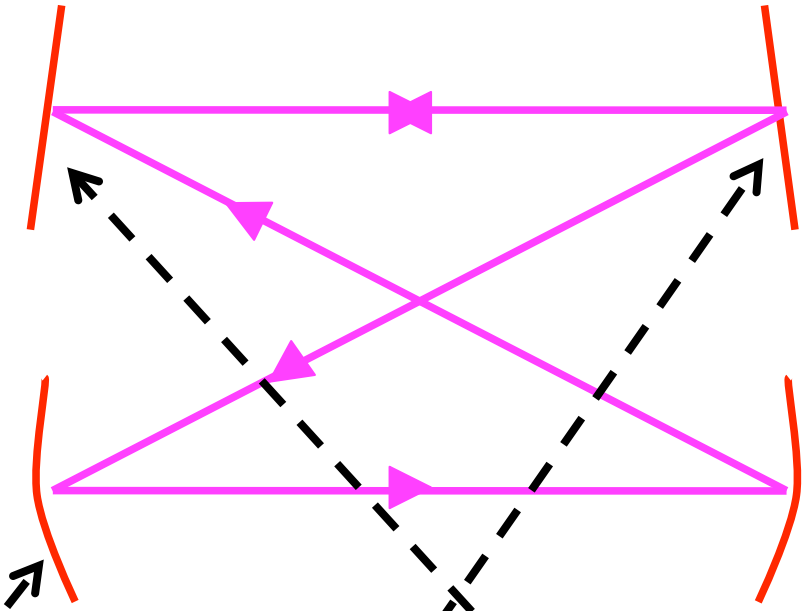




smaller δ
(smaller beam waist)

profile gets flattened

Image rotation during light propagation

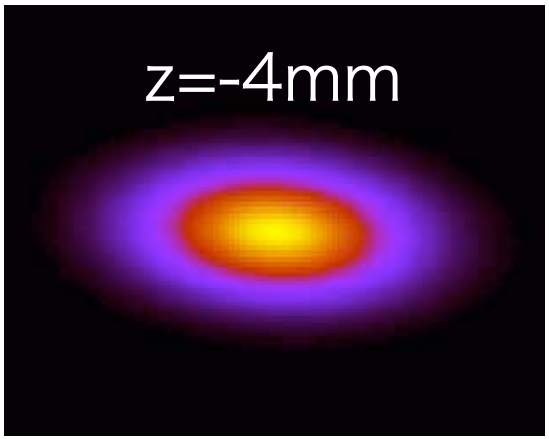


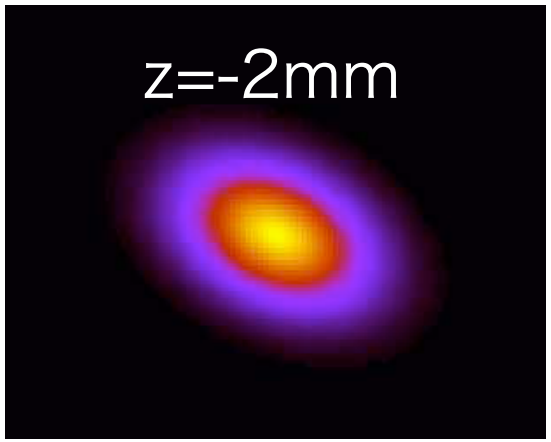
M(z)=D(L/2).R(θ).F(f2,f1).D(L).R(θ).D(L).R(θ).D(L).R(θ).F(f1,f2).D(L/2)

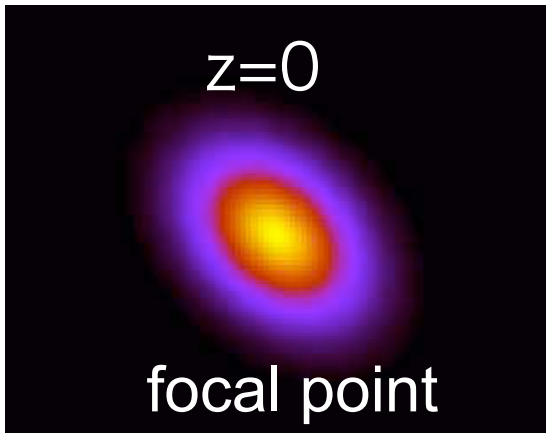
$$R[\theta] = \begin{pmatrix} \cos\theta & \sin\theta & 0 & 0 \\ -\sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & \cos\theta & \sin\theta \\ 0 & 0 & -\sin\theta & \cos\theta \end{pmatrix}$$

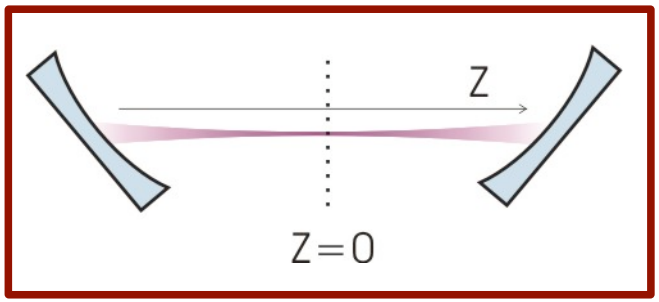
calculated profile around focal point

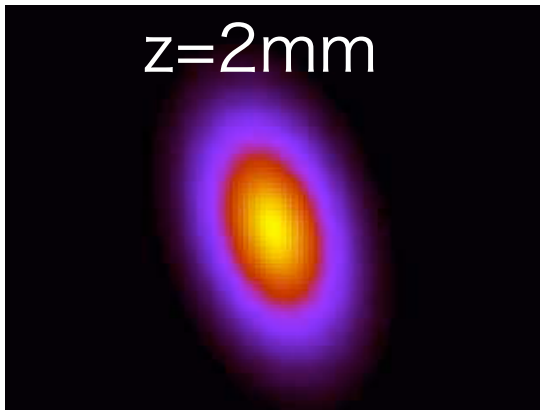
δ =0.2mm,

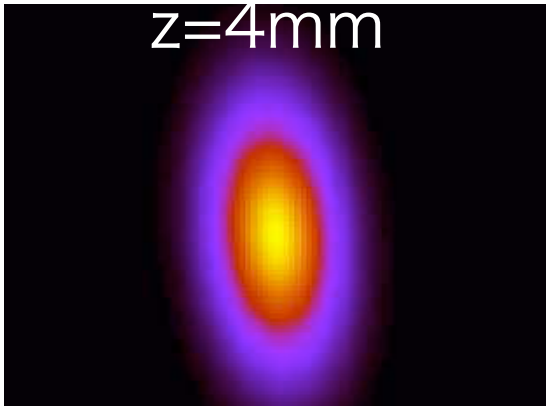








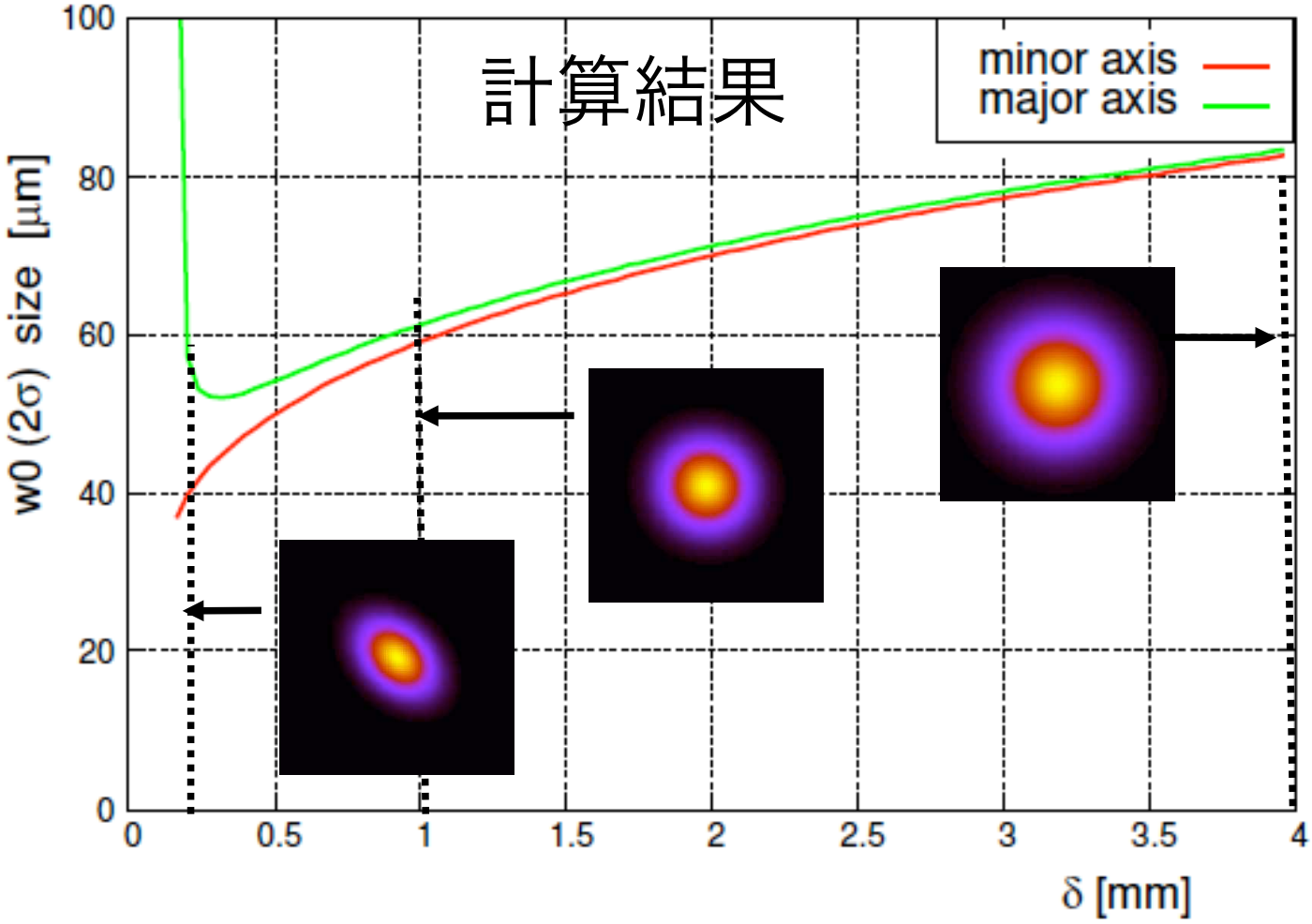


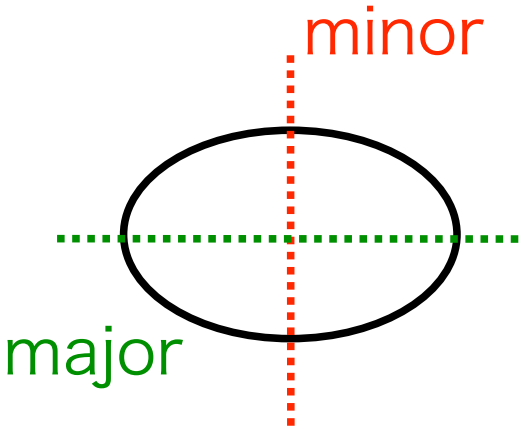


profile is rotating during its propagation!

angular momentum of light

spot size at the center of two focusing mirrors



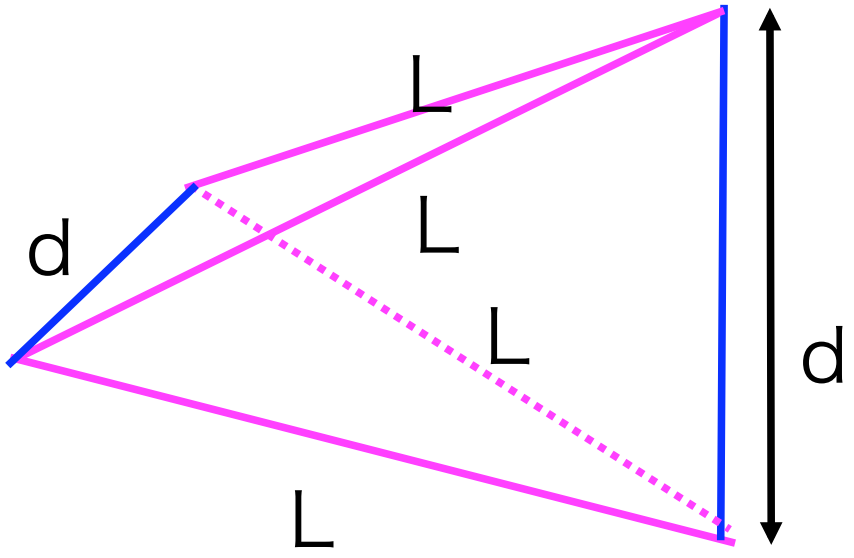


smallest with this prototype

2σ=(52μm、43μm)

need optimization for small waist size

waist size depend L and d



may be:
- longer L
- smaller d

current prototype
L = 420mm
d = 100mm
2σ=(52μm,43μm)

for L = 420mm
d=70mm:
2σ=(42μm,39μm)
d=50mm
2σ=(40μm,39μm)

Summary

- good experience and γ ray demonstration at the ATF with 2 mirror cavity

  setp by step and steady improvement

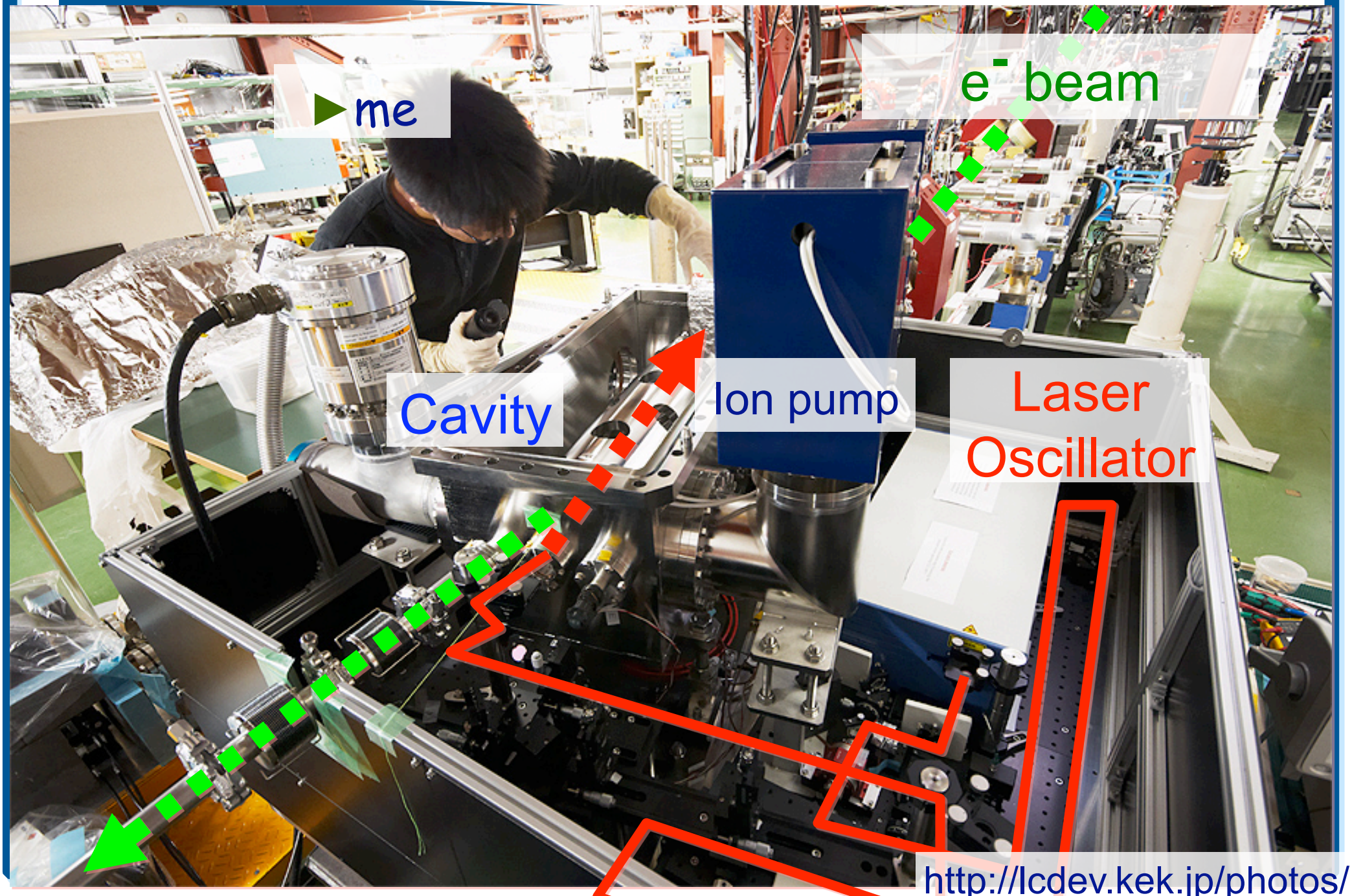
- progress understanding of 4 mirror ring cavity through prototype construction and calculation

  more complicated but interesting feature of 3D cavity

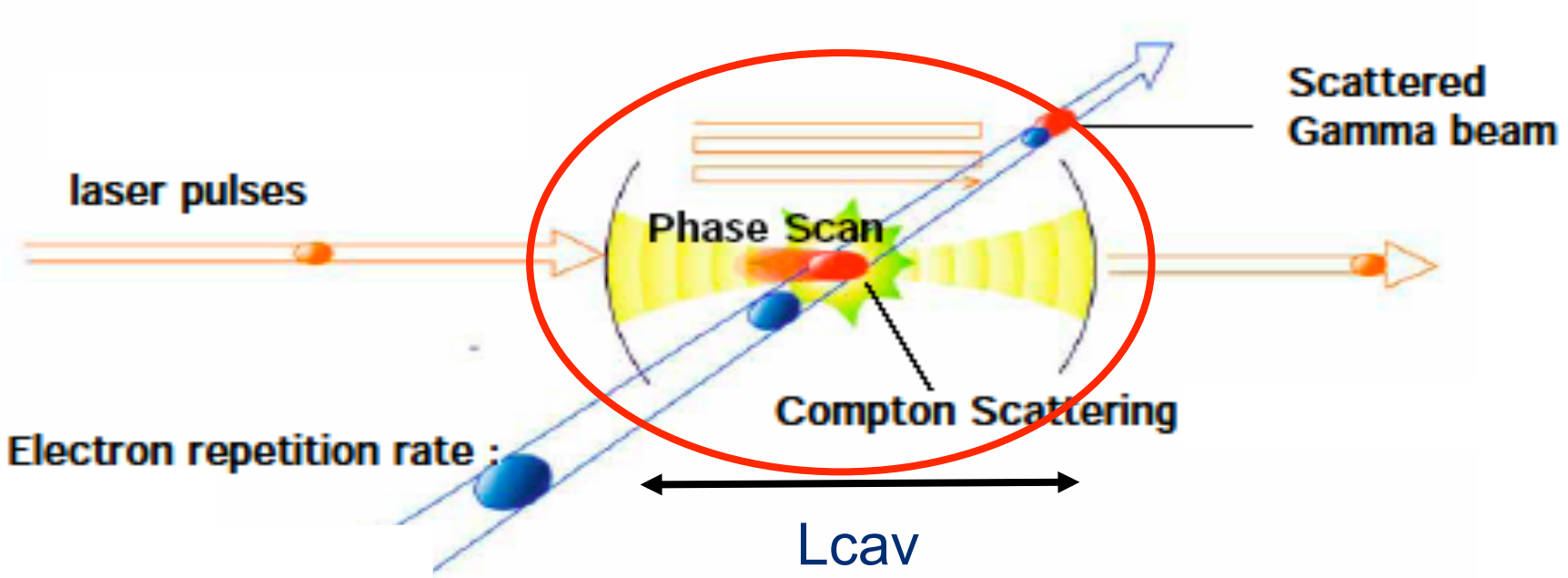
- In near future
  - bunch by bunch information more γ ray with 2M cavity
  - LAL 4M cavity in the ATF ring this summer

Experimental Apparatus



http://lcdev.kek.jp/photos/

Optical Cavity for Laser-Compton



Higher laser power

L_{cav} = n $\lambda/2$, ΔL<nm laser for pulse stacking

->more enhancement the more precision

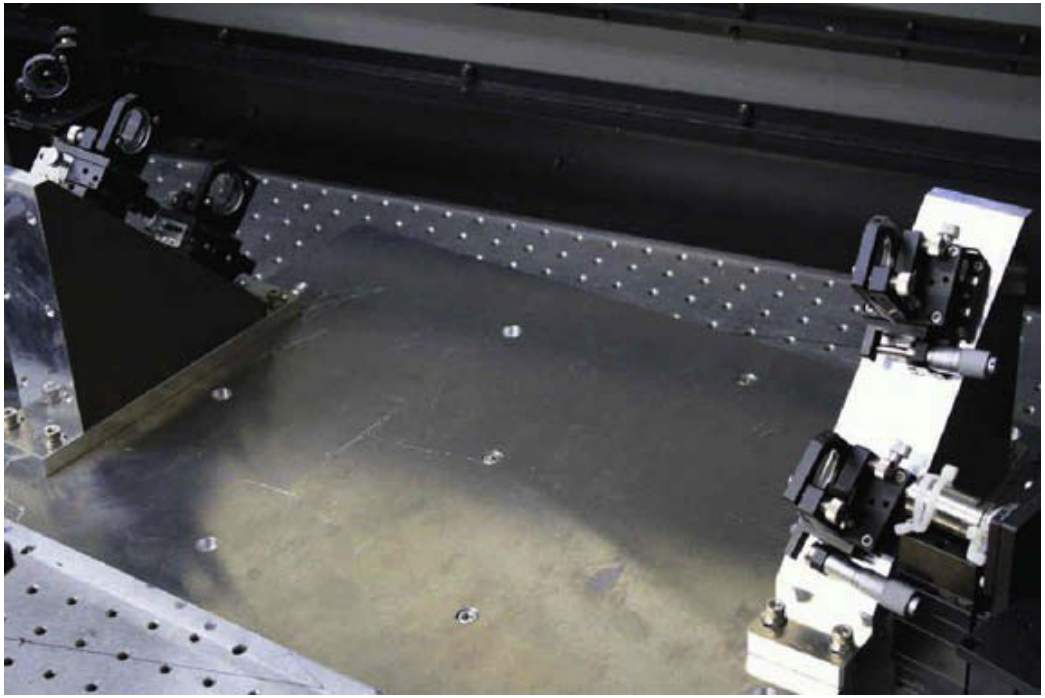
ΔT < ps

Laser should be focused for high power density

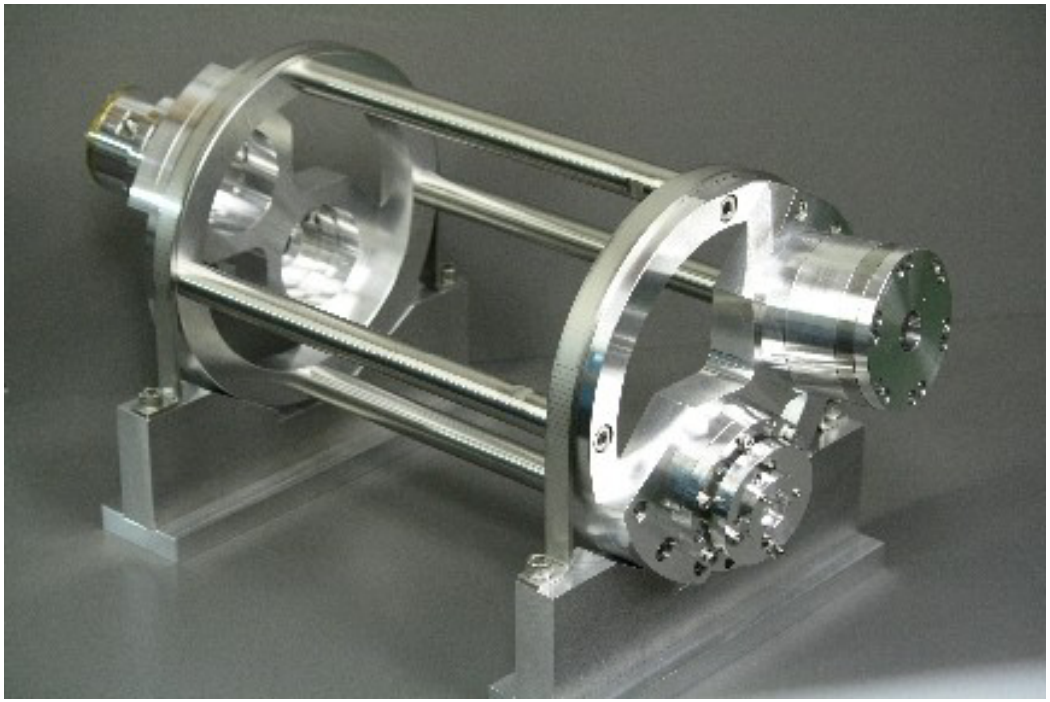
Accommodate laser cavity in the accelerator

4 MIRROR CAVITY STATUS

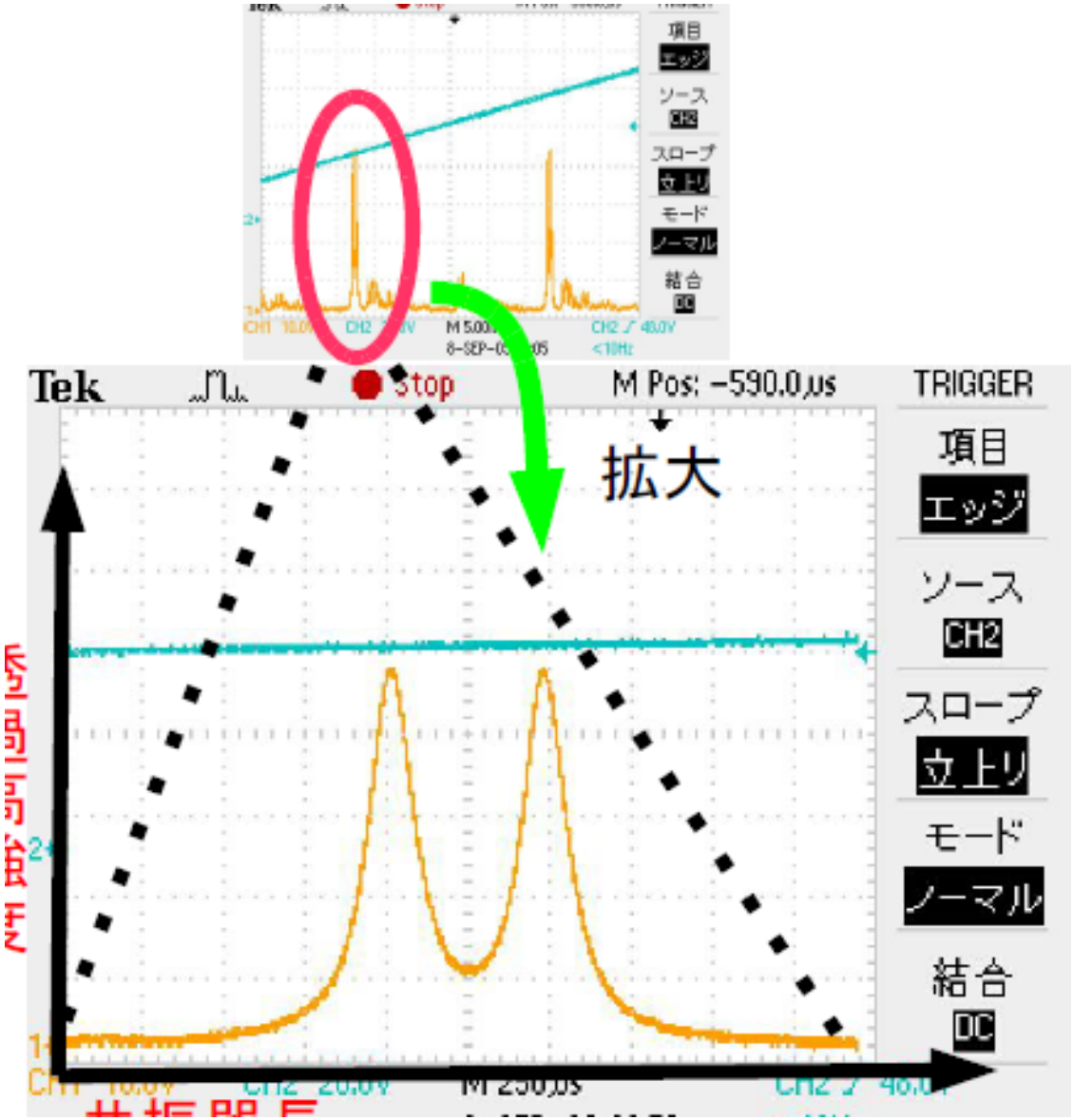
March 2009



August 2009



at ALCPG09



3D 4M cavity resonates with left and right circular polarizaton separately

This is due to geometric phase since light travels twisted path

but situation was more complicated