Status of Hiroshima-KEK Compton Experiment at ATF

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for Tsunehiko Omori (KEK)

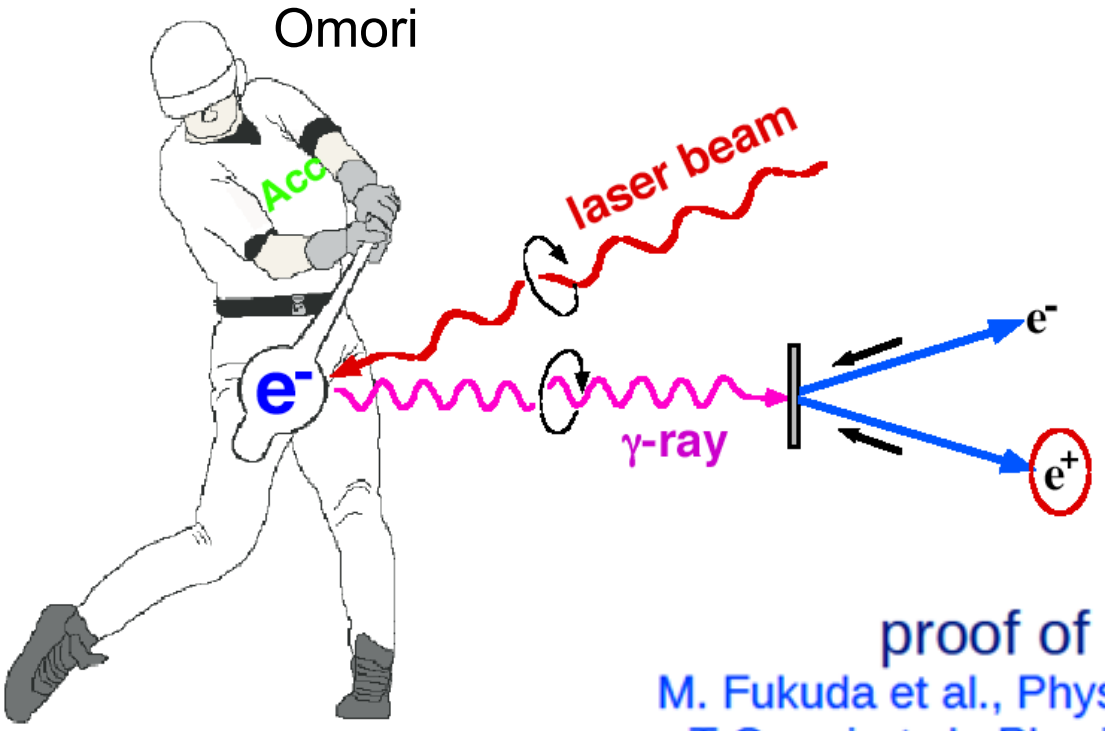
KEK – Hiroshima and close conatact with Waseda University, Seikei University and LAL Orsay

- Introduction
- Status of the cavity R&D
  - for Two mirror cavity
  - for four mirror cavity

March 2011
ALCPG11, Oregon

Introduction

- Polarized e+ by laser Compton Scheme



Ee~1GeV for 10MeV gammas

easy to control polarization

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

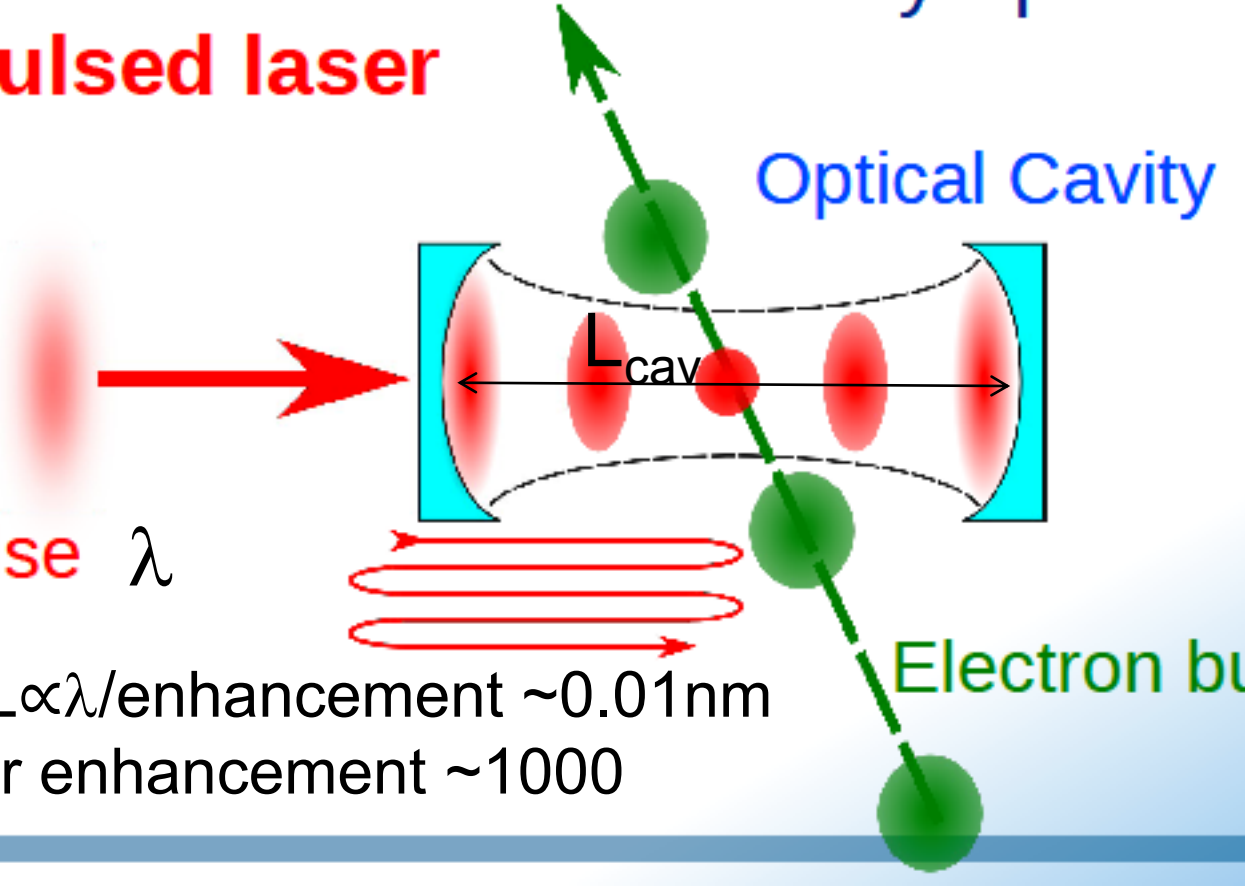
Miyoshi PosiPol2010

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**

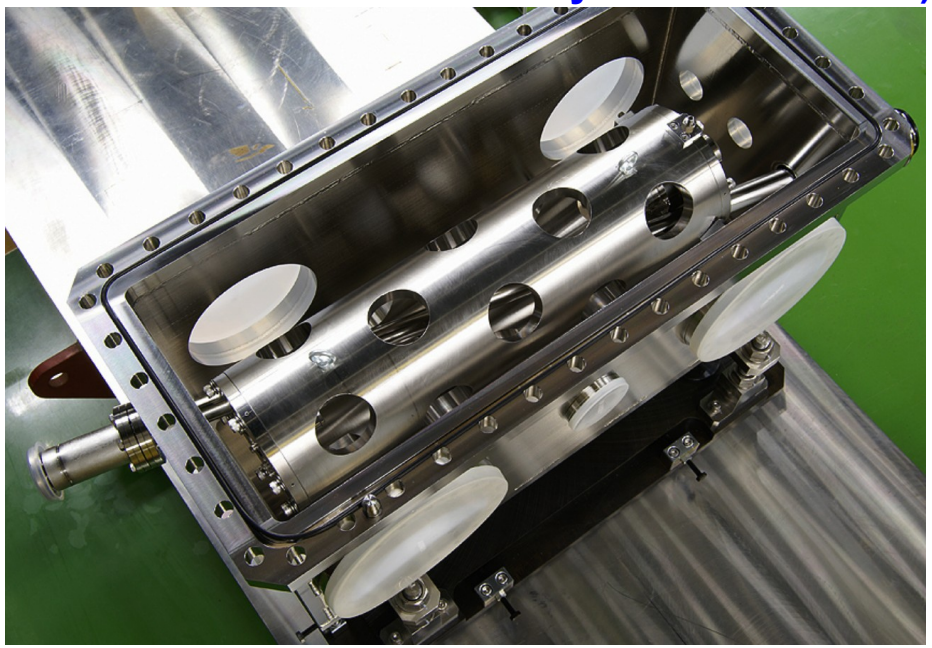


$$L_{cav} = m\frac{\lambda}{2}$$

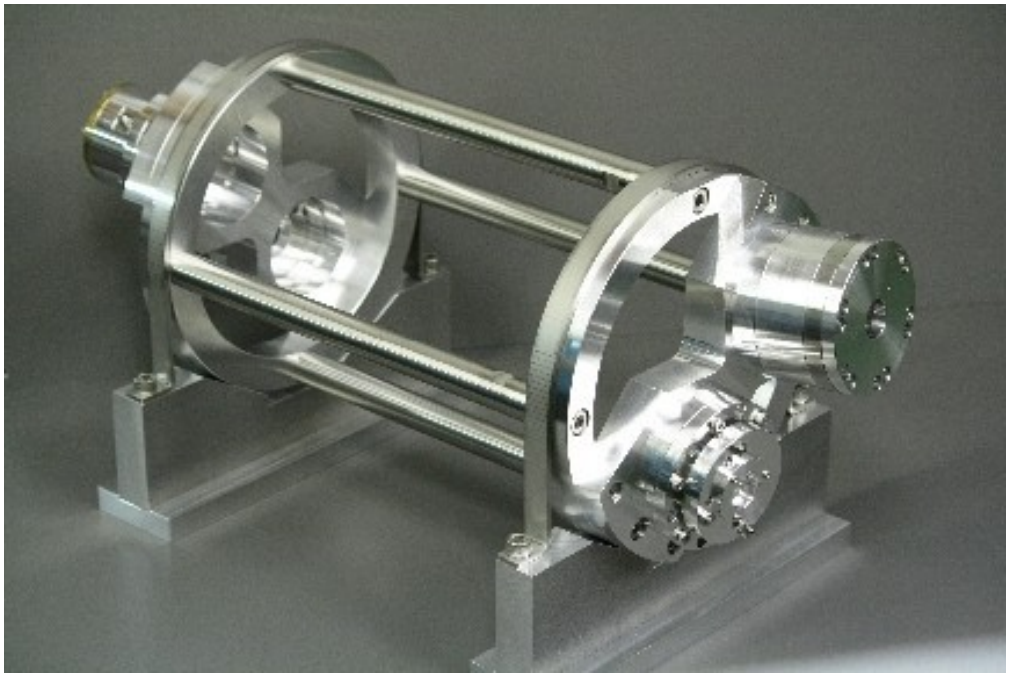
dL∝λ/enhancement ~0.01nm
for enhancement ~1000

Two Prototype Cavities

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



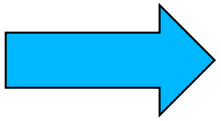
4-mirror cavity



moderate enhancement
moderate spot size
simple control

high enhancement
small spot size
complicated control

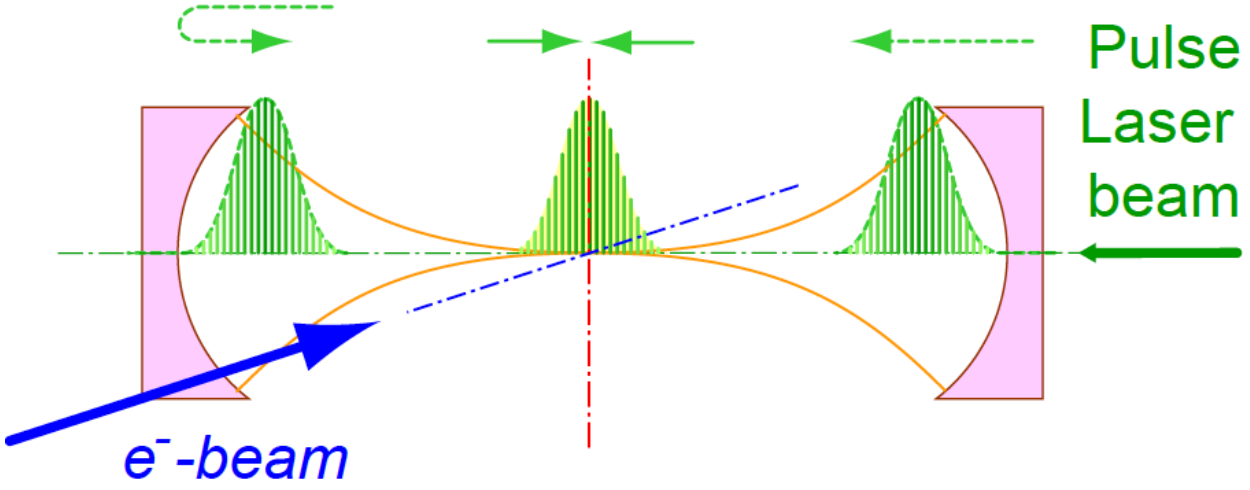
demonstration of γ ray gen.
accum. exp. w/ cavity and acc.



intense γ ray generation

Experimental R/D in ATF

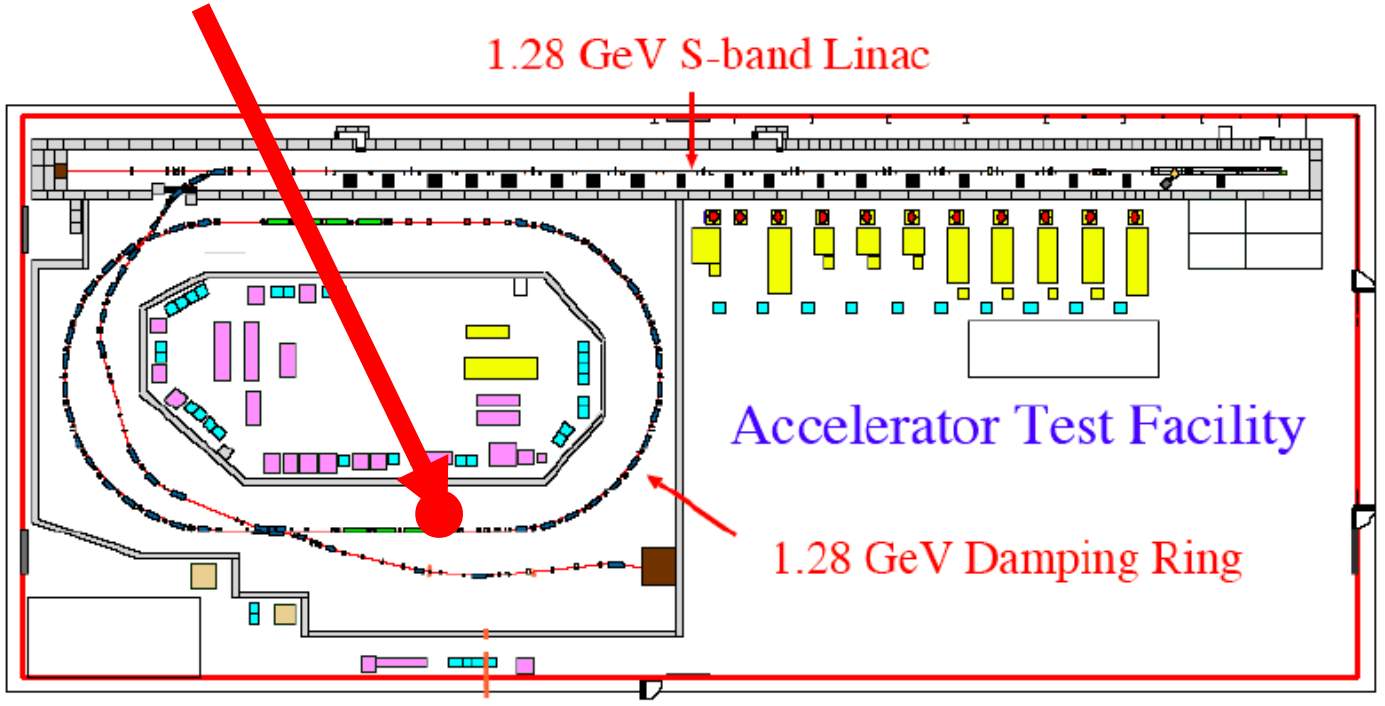
Hiroshima-Waseda-Kyoto-IHEP-KEK



Make a fist prototype 2-mirror cavity

L_{cav} = 420 mm

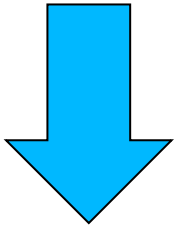
Put it in ATF ring



Progress of the 2M cavity

- 2007/2008 -- installed into the ATF
  - γ ray generation w/ 250 enhancement but not well synchronized w/ e-
- 2008/2009 --- synchronized w/ e-
  - 500W, γ ray generation
- 2008/2009 -- more encasement (750)
  - 2.5kW, γ ray generation

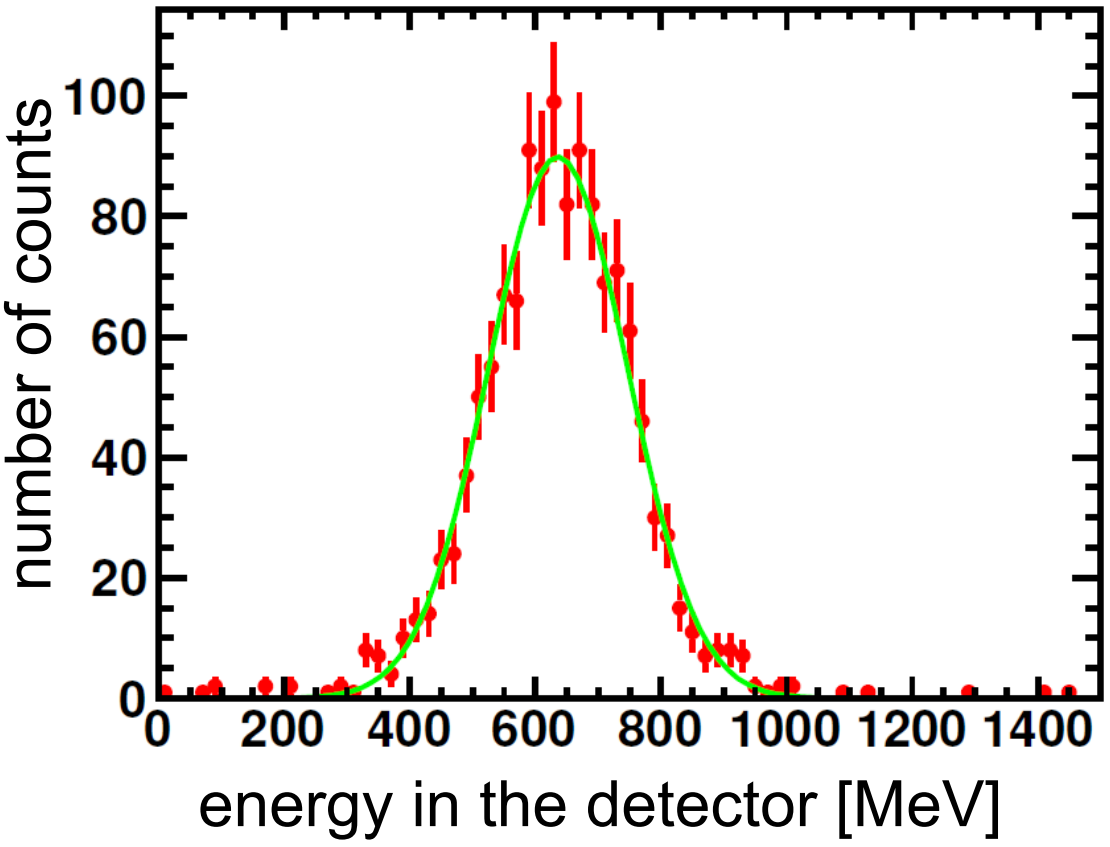
reported in previous meeting



- 2010-
  - bunch by bunch measurement

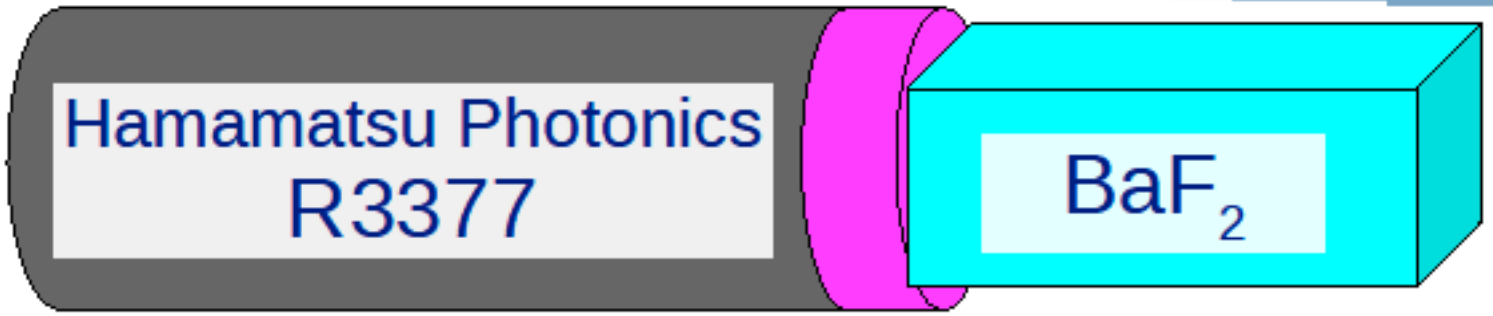
in 2010 operation

- laser power
  - enhancement 750
  - stored 1.5kW
- γ rays
  - 10 bunches
  - ~10 γ/bunch in the detector

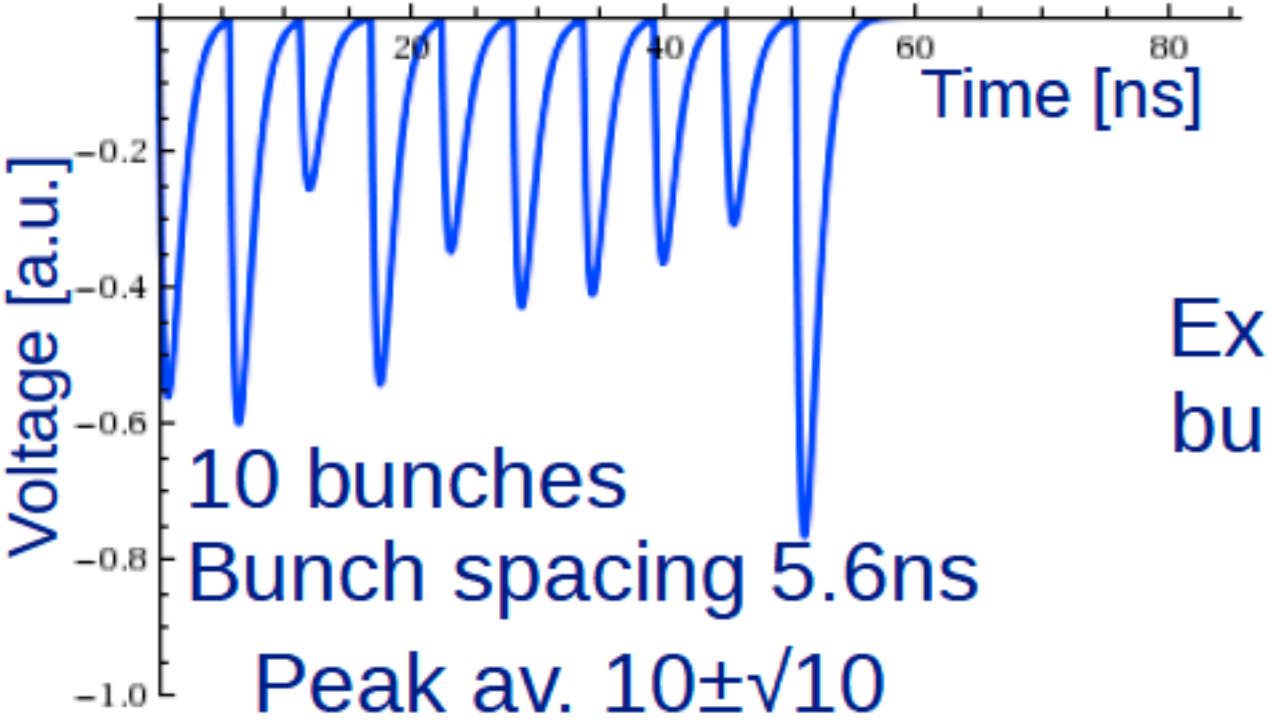


New Gamma-ray Detector

Miyoshi PosiPol2010



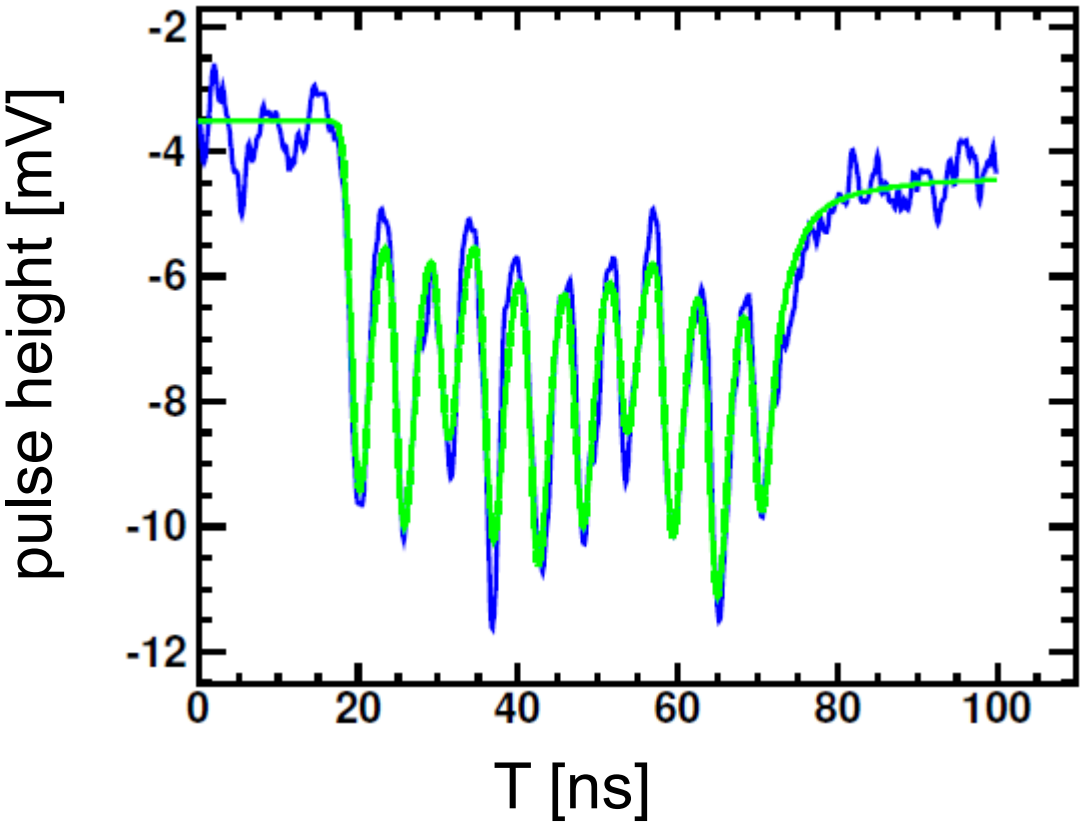
Result of simulation



10 bunches
Bunch spacing 5.6ns
Peak av. 10±√10

Expected to obtain bunch information.

Observed signal with 10 bunch



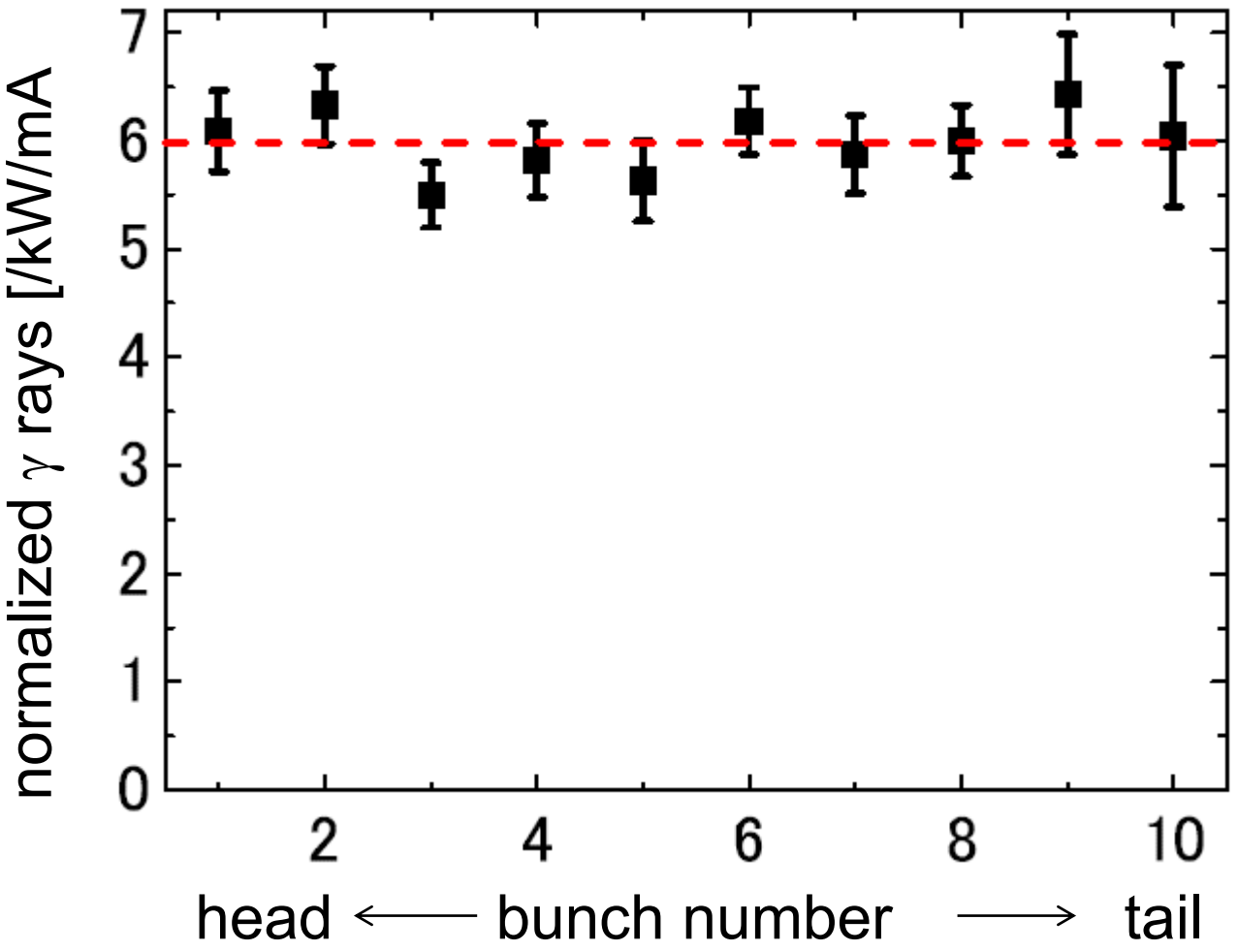
Fitted w/ scintillation + detector response

$$P(t) = \frac{A}{2\pi\sigma\tau}\int_0^{\infty} e^{-\frac{x}{\tau}} e^{-\frac{(t-x)}{2\sigma^2}}\, dx$$

$$= \frac{A}{2\tau} e^{\frac{\sigma^2 - 2t\tau}{2\tau^2}}\, Erfc\left(\frac{\sigma^2 - t\tau}{\sqrt{2}\sigma\tau}\right)$$

+ ,,,,,,,,,,

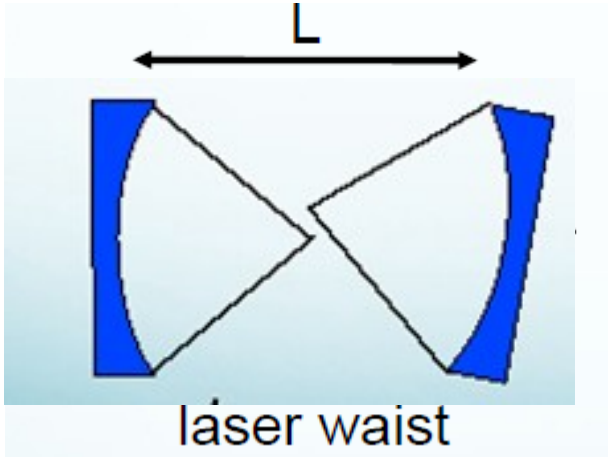
bunch by bunch γ rays



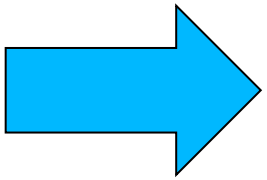
no bunch position dependence in a train

absolute # is consistent w/ estimation

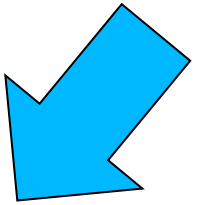
We should go to 3D 4 mirror ring cavity to get small spot size

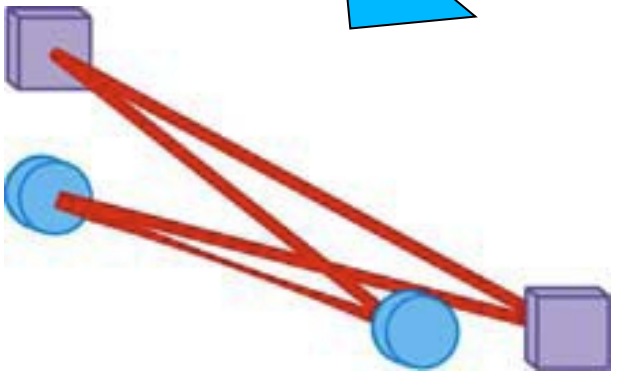


2 mirrors is not stable for small spot size



2d 4M has astigmatism

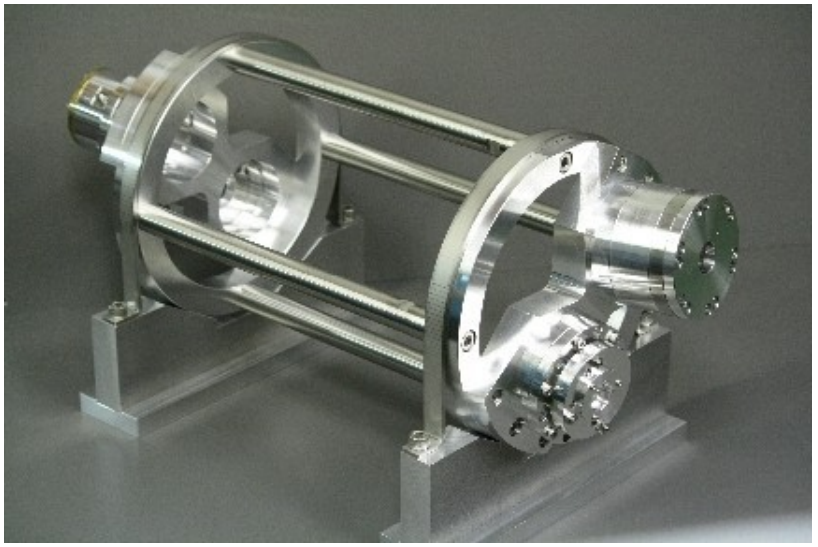




3D (or twisted) 4M ring cavity

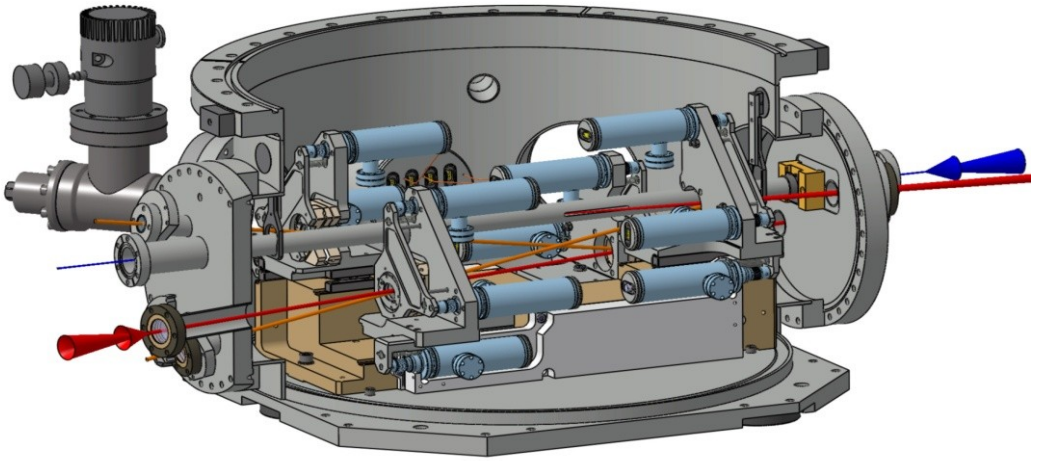
Two 4 mirror cavities are installed at the ATF

KEK-Hiroshima
to be installed summer 2011



relatively simple control system
employ new feed back scheme
w/ exiting laser system

LAL-Orsay
installed summer 2010



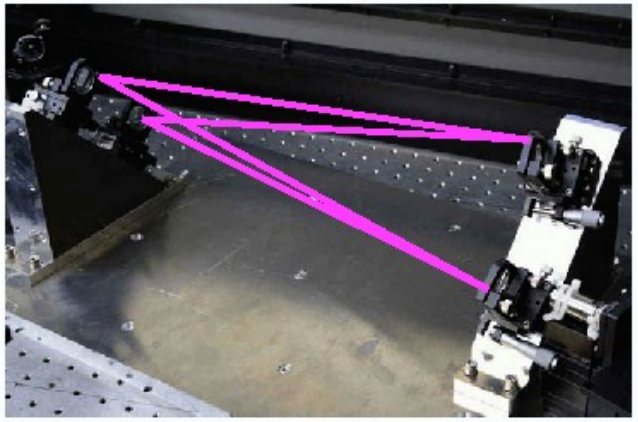
all mirrors are remotely controlled
sophisticated PDH feedback
high power accumulation
w/ fiber lasers

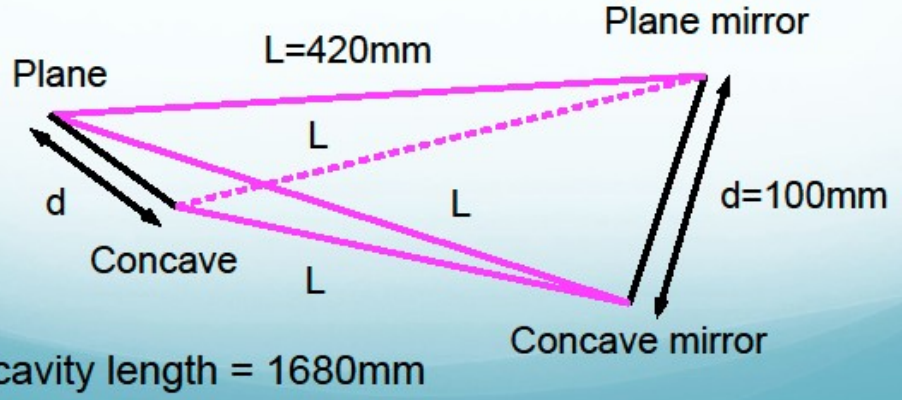
See Zommer's talk

4M cavity test bed at KEK

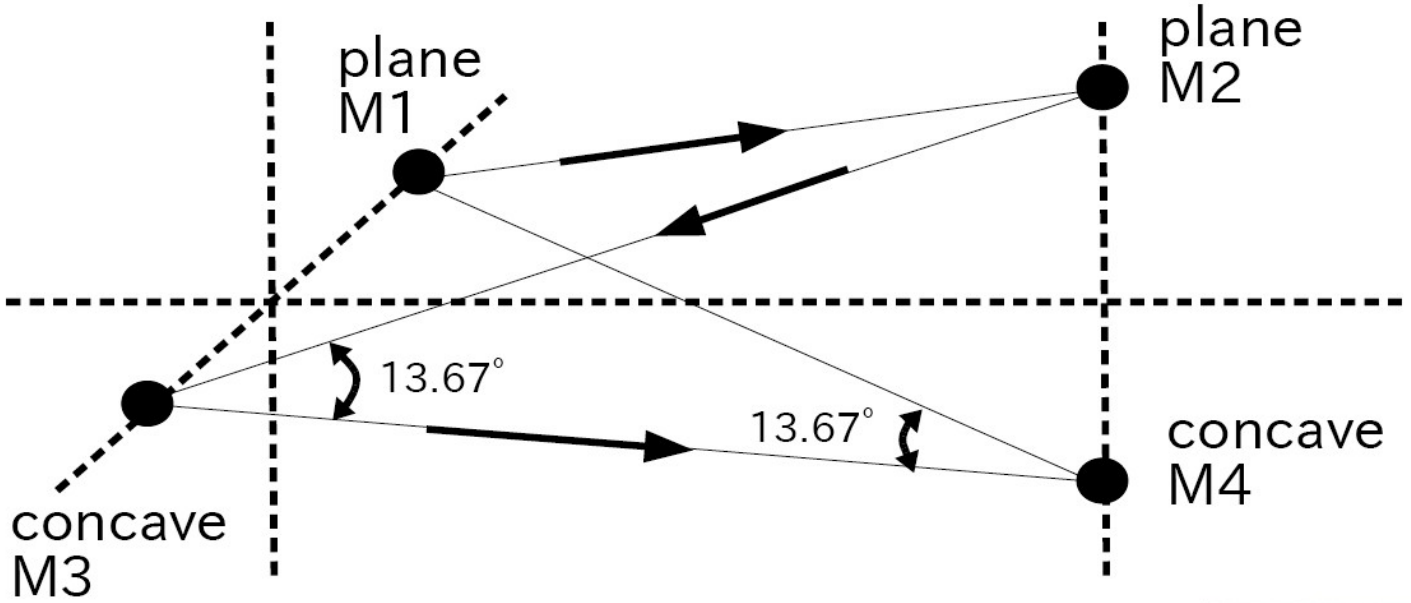
- in 4M ring cavity, photons travel twisted path.
  - got geometric phase
    - the cavity only resonate w Lr or R handed state
  - and more,,,

need detail study by
the comparison of measurement s and calculation.



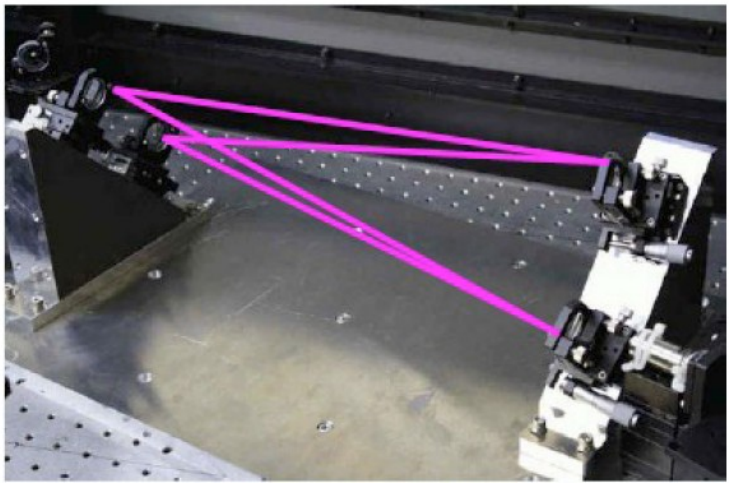


Configration of test bed

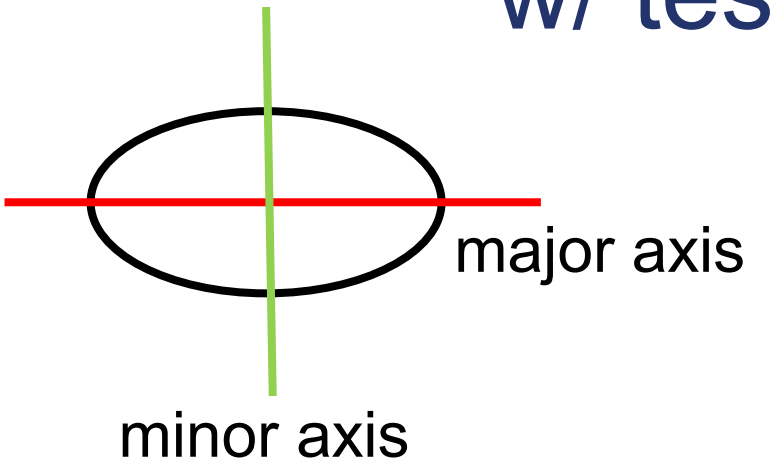


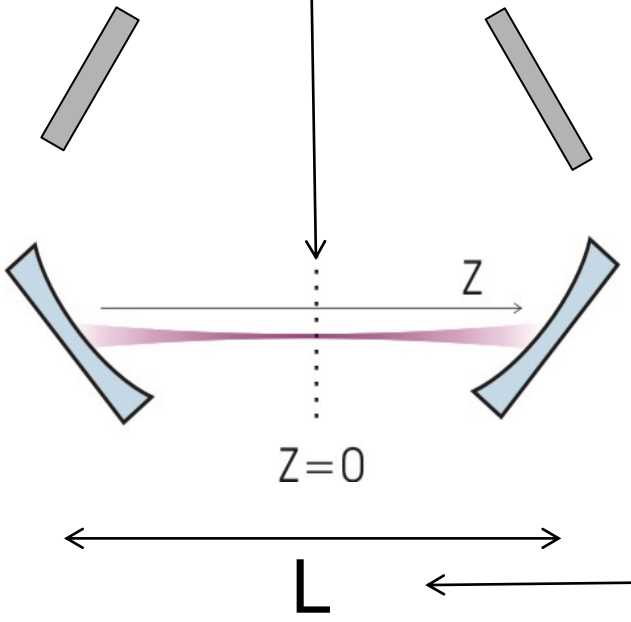
L1=M1-M2=420mm
L2=M2-M3=420mm
L3=M3-M4=420mm
L4=M4-M1=420mm

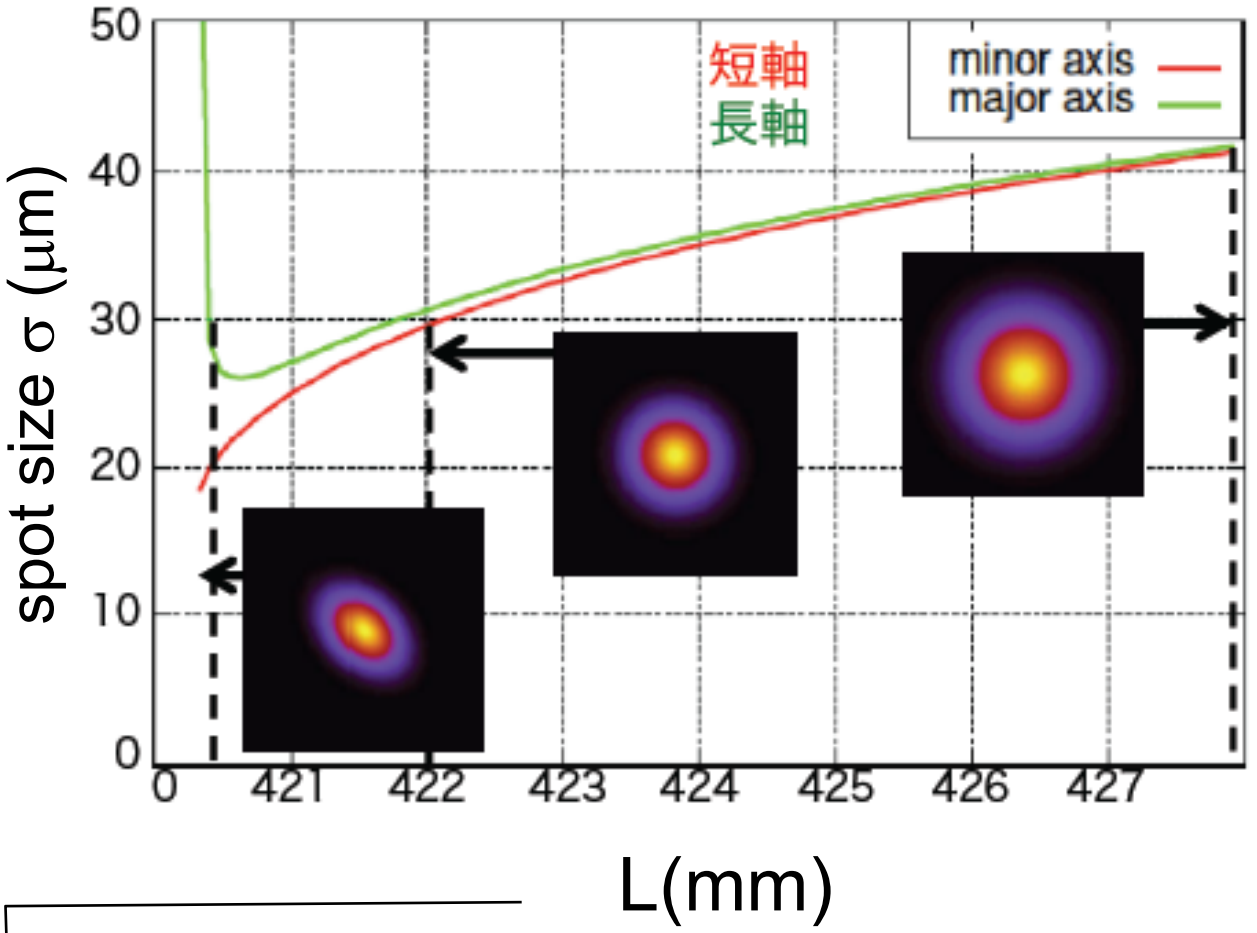
M2-M4=100mm
M1-M3=100mm



calculation of spot size w/ test bench geometry

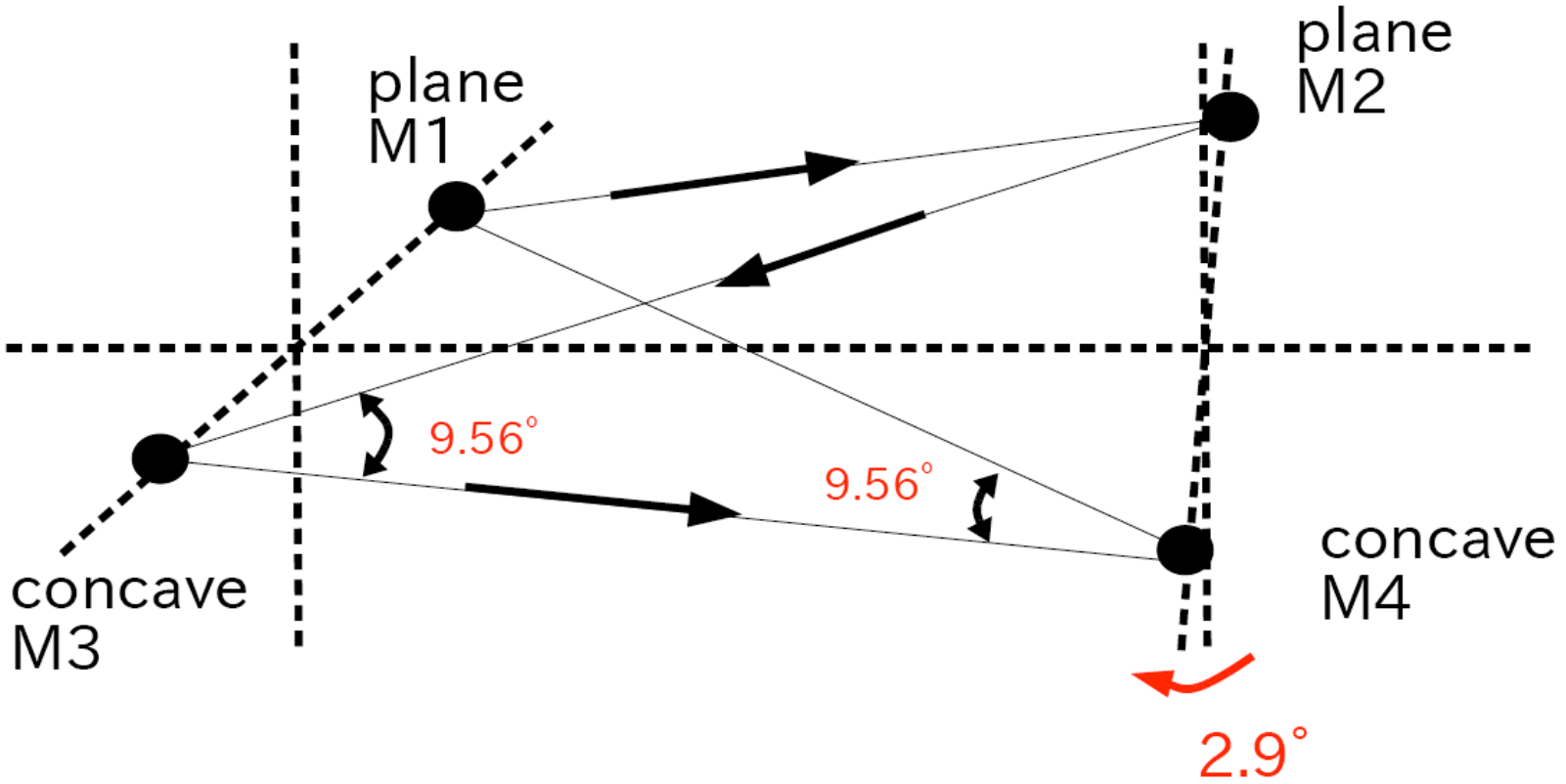






spot size is not sufficiently small with test bench geometry

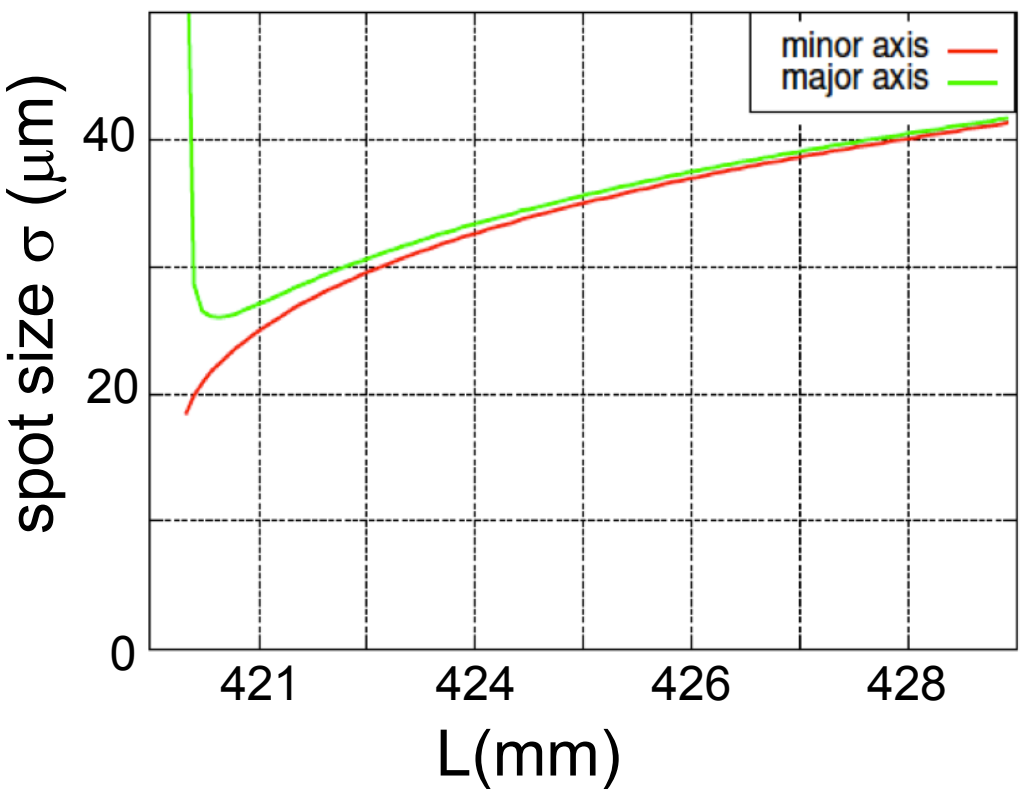
new geometry

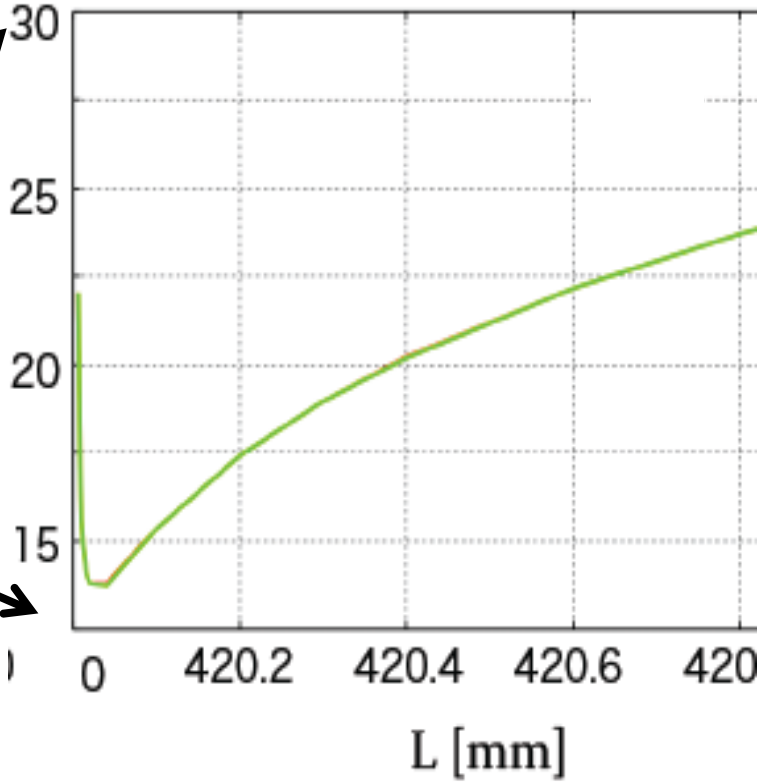


L1=M1-M2=420mm
L2=M2-M3=420mm
L3=M3-M4=420mm
L4=M4-M1=420mm

M2-M4=70mm
M1-M3=70mm

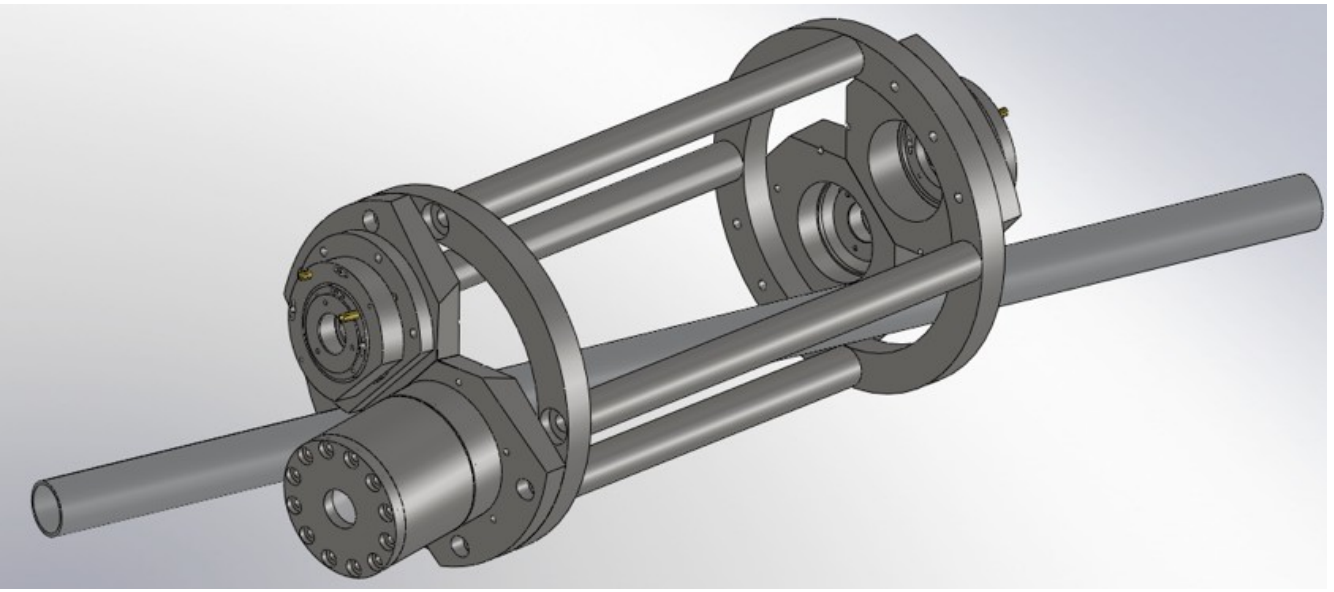
expected spot size w/ new geometry

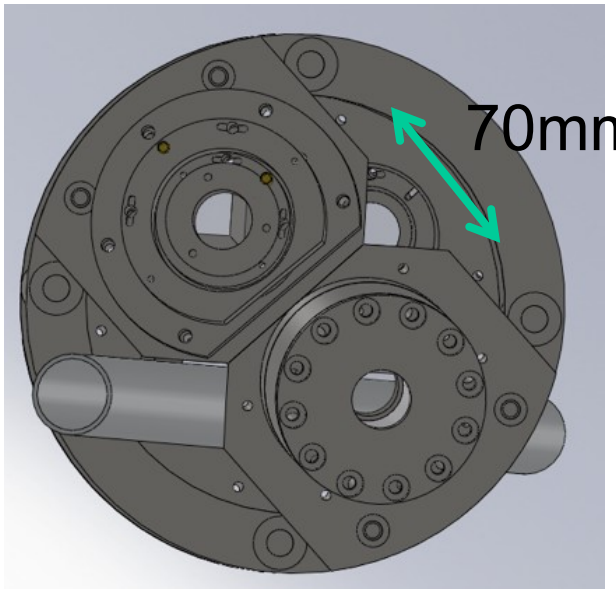


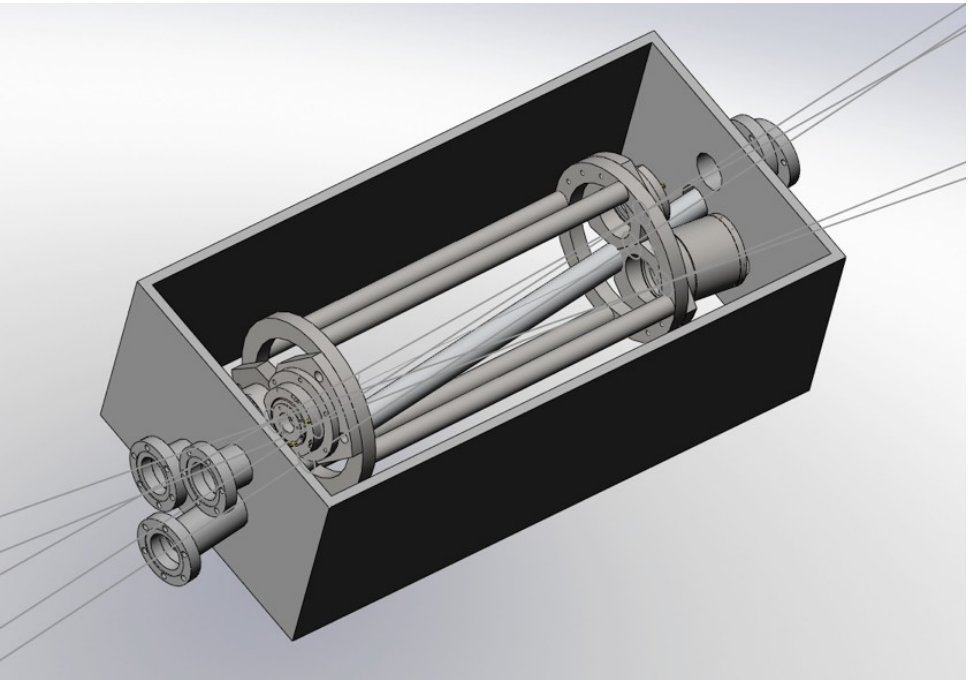


laser spot size of 15 μm is expected with new geometry

new cavity







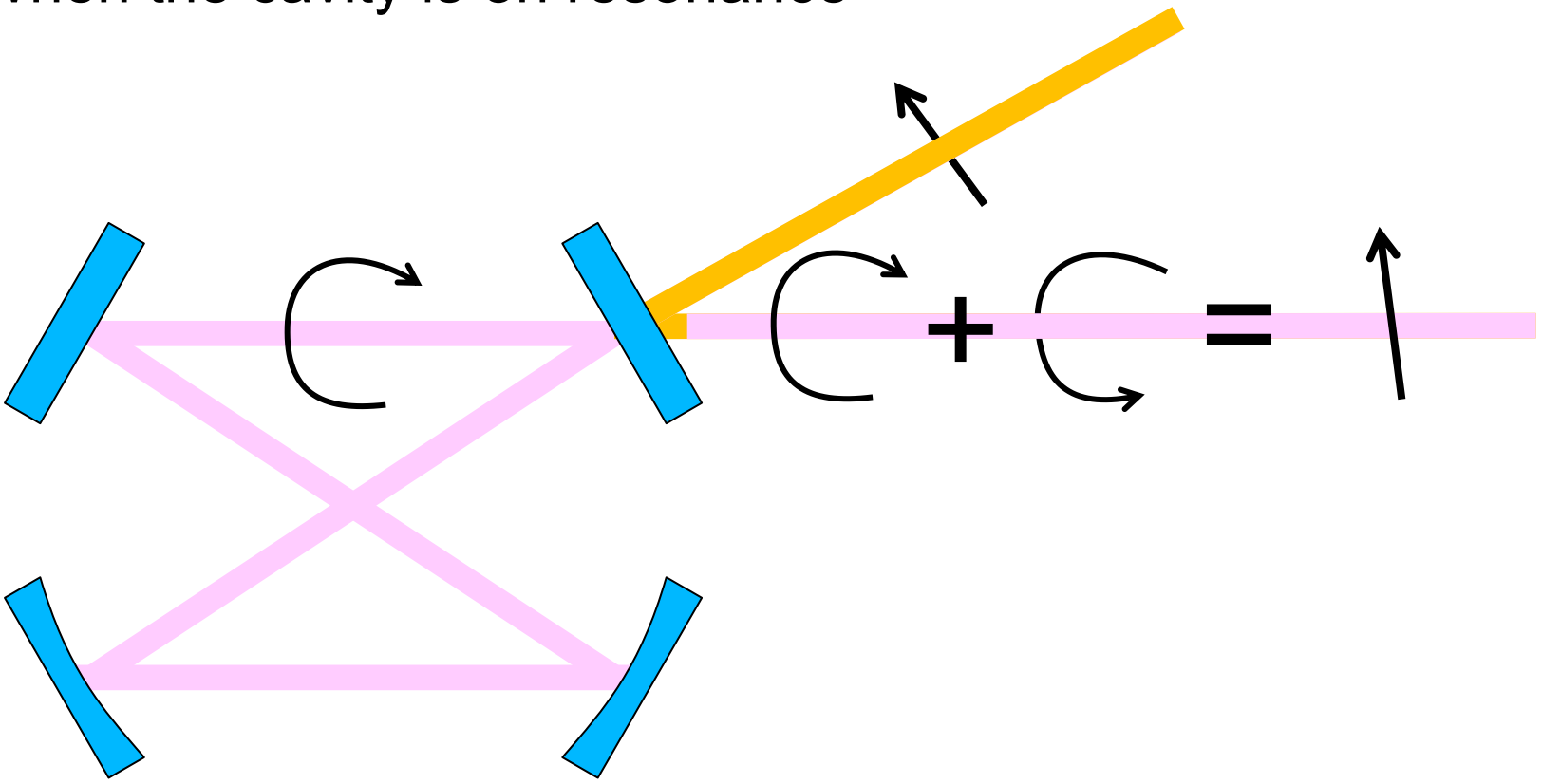
based on calculation for optimization

design being finalized
to be installed summer 2011

feedback with 3D feature

3D4M cavity resonate only with
circularly polarized lasers

When the cavity is on resonance

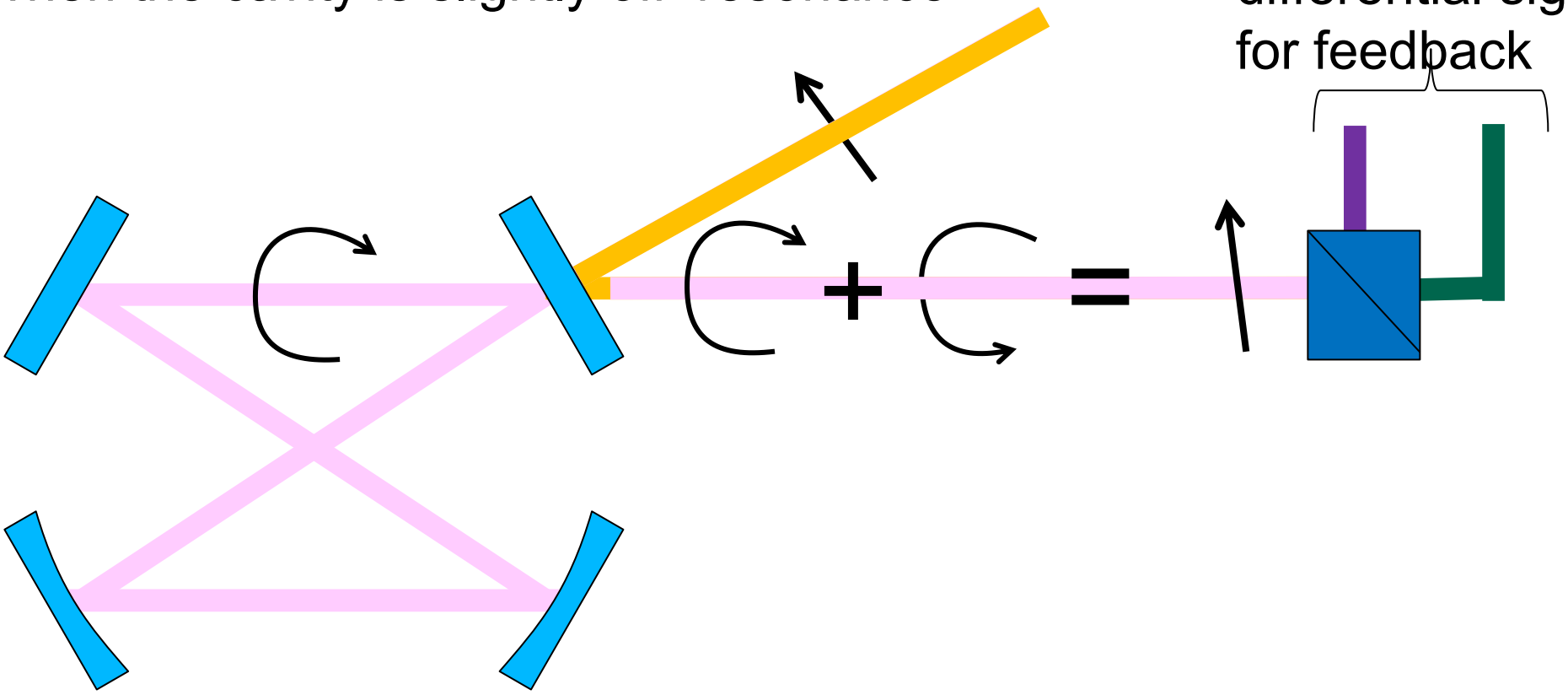


feedback with 3D feature

3D4M cavity resonate only with
circularly polarized lasers

When the cavity is slightly off resonance

differential signal
for feedback



summary

- Compton experiments are on going
  - experience w/ two mirror cavity
    - 750 enhancement
    - multi-bunch measurement
  - new four mirror cavity is under construction
    - finalize design soon (Mar. 24)
    - hopefully installed summer 2011
    - new feedback scheme is understudy
- ATF will be back !